COMPRESSED AIR

AND EVERYTHING PNEUMATIC

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THE LARGEST PLANER

The largest and heaviest metal working planer ever built, recently completed at the Philadelphia Bement-Miles works of the Niles-Bement-Pond Company, for Mackintosh-Hemphill Company of Pittsburg, is not only of interest as a whole to all who have to do with machine construction and operation but possesses special features for the consideration of the readers of COMPRESSED AIR.

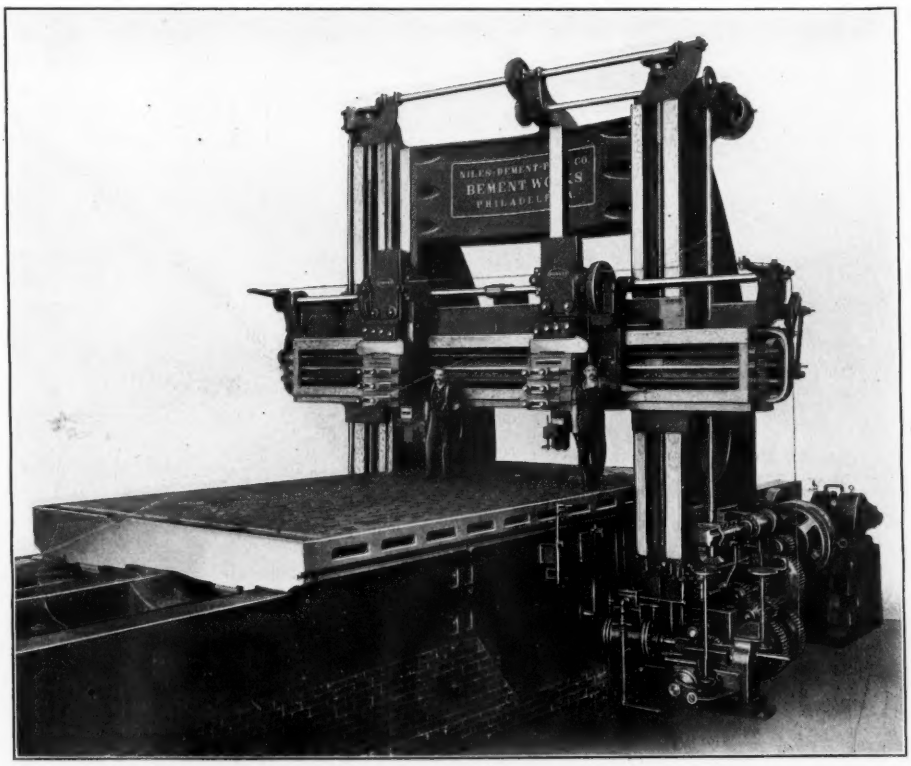


FIG. 1. FRONT OF PLANER.

This is a special machine not only as to size but in many of its details. It is, in fact, a combination machine, doing not only regular longitudinal planing but also cross and vertical planing or slotting. That it should be presumably profitable both to build and to purchase and use such a machine as this is a striking evidence of the growth of the business of machine and engine construction, not only as to the size of the units produced but also as to the number of them to give sufficient employment to such a machine. It is to be used for machining heavy engine beds, rolling mill forms, etc., the first job which came to it being a bed weighing 94 tons.

The total weight of this planer is 845,000

pounds, or 422 tons, and it requires a total of 207 horse-power in the motors for the main drive and the several operating or auxiliary movements to be provided for. The distance between the uprights is 14 feet 4 inches, and from the top of the platen to the under side of the cross rail is 12 feet 2 inches. The longitudinal travel is 30 feet. The motor for the main drive is 100 horse-power, this power being transmitted by gearing to reversing pneumatic clutches of the well-known Niles-Bement-Pond type. These clutches are usually operated from a shop air supply but in this instance a compressor with a 30 horse-power motor is a part of the machine. A small valve easily operated controls the starting, stopping and reversing. Tripping this valve by the familiar table dogs gives the automatic reverse to the reciprocating movement.

The pneumatic feed, which is a novel feature of this machine, calls for special mention. This feed has fewer parts and greater strength than the usual mechanical feed. The application of this feed to the crosshead may be clearly seen in Fig. 2. On the side of the upright just above the gearing is a horizontal cylinder with piston rod extending to the left. This rod slides a rack which meshes with a gear near the bottom of the vertical feed shaft. This feed shaft has on its lower end a bevel gear meshing with a bevel gear on a cross horizontal shaft which transmits motion to a vertical feed shaft on the other side of the machine. The movement of these feed shafts is constant under all conditions, and variation in the amount and direction of the head feeds is obtained by adjusting the connecting rods in the slotted cranks on the ends of the cross slide. The feed cranks are so graduated that very precise movements of both the vertical and the cross feeds are produced and combinations of these thus give angular feeds, the heads not being made to swivel. The valve for controlling the air operating the feed cylinder is moved automatically at each end of the stroke, this movement being taken from either the main driving gear train to the platen, or the slotter gearing when slotting. To disengage the feed it is simply necessary to close a valve and shut off the air.

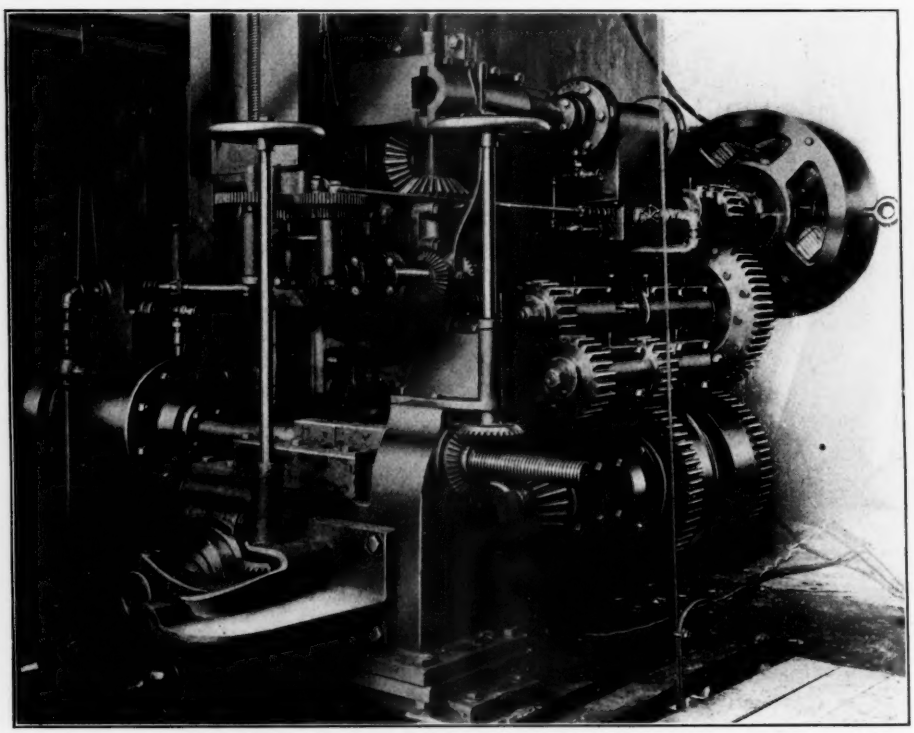


FIG. 2. PNEUMATIC FEEDS OF PLANER.

The feed mechanism for the table which is required when slotting or cross-planing is seen in Fig. 1 directly in front of the base of the upright. This feed operates practically the same as the feed for the crosshead, except that variation in the amount of feed is obtained by an adjustable stop which limits the piston movement. This adjustment is made by the hand wheel at the right, the hand wheel at the left connecting this feed mechanism to the main driving works.

Fig. 3 shows the base of the left hand upright with the 50 horse-power motor for slotting and cross-planing, and the pneumatic clutch and reversing mechanism. Just above the motor is seen the reversing disc for both slotting and cross-planing. The dogs on the periphery can be set to give any stroke. Bevels on the vertical square shaft above the cross rail, not here seen, are used for changing the drive from slotting to cross-planing.

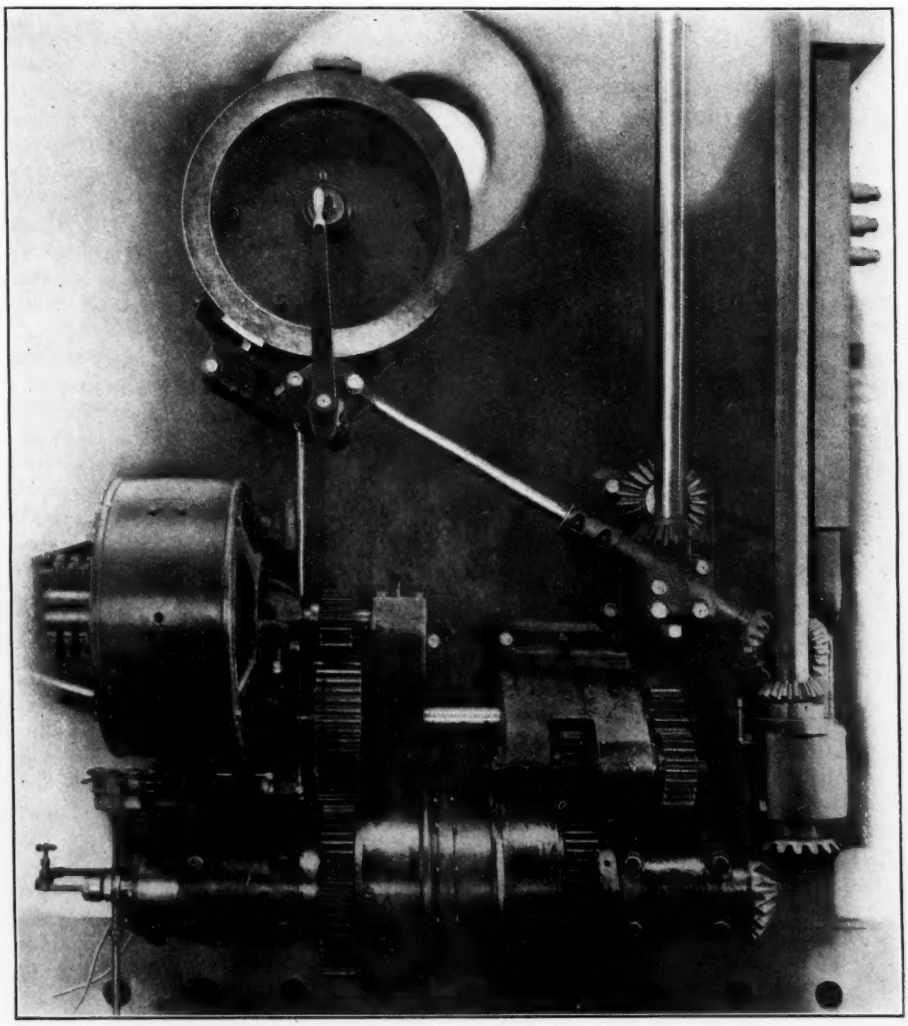


FIG. 3. MOTOR FOR SLOTTING AND CROSS PLANING.

The planer, as was said, has its own compressor driven by a 30 horse-power motor and maintaining a constant pressure in a large storage reservoir, thus making it independent of a shop supply, which, however, may be con-

nected for emergent use. The table is 32 feet long, 14 feet wide, and slides on three ways each 15 inches wide, the center way being an obtuse vee and the outside ways flat. The holes in the top of the table for stops, bolts, etc., extend entirely through the upper plate, below which is a second plate without openings for catching the chips, which may be raked out through the holes in the sides.

The bed is 60 feet long, 13 feet wide and the central part is 73 inches deep. In the ways of the bed are oil pockets and rollers for lubricating the table; one pocket is centrally placed and all are connected to maintain a common oil level. The central section of the bed is divided longitudinally into three parts and the two end sections each into two parts. The total weight of the bed is about 275,000 pounds. The table is divided longitudinally in the center and weighs 140,000 pounds.

THE TUNNEL AND RIVER SHAFT OF THE DETROIT WATER WORKS*

By James Ritchie.

Before making a contract for this work the city of Detroit had built a tunnel from the pumping station to a point near the bank of the Detroit River, a distance of about 1000 feet, and had constructed a gate chamber and a shore shaft with 50 feet of river tunnel. The shore tunnel was 10 feet inside diameter and was placed with its axis at a distance of 26 feet below the surface of the ground. The shore shaft had an inside diameter of 10 feet and a total depth below the surface of the ground of 78 feet 6½ inches. The axis of the river tunnel was at a distance of 69 feet below the surface of the ground, or 63 feet below the surface of the water in the Detroit River. The inside diameter of the river tunnel was 10 feet, and the tunnel was constructed of four rings of shale brick laid in Portland cement mortar. The diameter of the excavation was 13 feet. After completing the first 50 feet of the river tunnel, the city put in a timber bulkhead and prepared to let a contract for the rest of the tunnel, the river shaft and the intake crib and crib house.

The contract for the river tunnel and shaft covered 3,185 feet of tunnel from the end of the 50 feet built by the city to a point 75 feet beyond the center of the intake crib, and a river shaft of 10 feet inside diameter placed at the center of the crib. The end of the tunnel was finished by two bulkheads 25 feet apart, to permit of a second crib and shaft being constructed should it be determined to extend the tunnel.

Work was commenced on the ground at the shore shaft on May 1, 1904, and consisted of setting up the machinery, building engine and boiler house, cement shed and offices, installing the elevator supports and preparing for the work of construction while awaiting the arrival of the materials. The power plant consisted of two boilers, one Ingersoll and one Rand air compressor, each 18 by 24 inches, one electric generator and engine for operating same, one elevator hoisting engine, two drainage pumps for removing water from the tunnel and one boiler feed pump.

On June 14, 1904, we commenced laying brick, and continued without using compressed air until we had completed about 40 feet, when work was stopped in order to install the air locks. These were two in number, the working lock being 5 feet 6 inches in diameter and 22 feet long, set on the bottom of the tunnel and enclosed in brickwork and cement, and the emergency lock above the working lock, to be used in case of accident. The emergency lock was at all times open to the tunnel, so that if the working lock were closed the men could escape any danger by entering the upper lock, closing the door and locking out towards the shore shaft. Underneath the working lock was a 6-inch iron pipe for blowing off the tunnel, provided with a valve on the atmosphere end, and above the lock was a pressure regulating pipe with a safety valve on the atmosphere end, by which the tunnel could be ventilated by raising the pressure above that at which the safety valve was set. Compressed air was furnished to the face of the work through a 5-inch pipe, which was carried along as the work progressed, and the end of which was at all times within 50 feet of the working face. Water was carried to the face through a 2-inch pipe and kept close enough to the work to supply the mortar boxes through 25 feet of hose. Electric light wires and telephone wires at all times extended to the face and maintained light and communication. The telephone gave us the most trouble, as the instru-

*Read before the Civil Engineers' Club of Cleveland, Slightly abridged.

ments could not stand the atmospheric conditions for any great time without repair, but they were well worth any trouble that they caused us.

After the air locks were in position and found to stand the pressure, work was continued excavating and bricking-in without serious delay, and the only stops made were on Sundays and holidays. Each Sunday the tunnel was thoroughly cleaned and ventilated, wires overhauled, telephone adjusted and other necessary work on the plant performed, ready for the night shift to go on at 11 o'clock. There were two shifts of miners, one going on at 11 P. M. and the second at 7 A. M. The bricklayers went on at 3 P. M. and bricked up what had been excavated by the mining shifts. For about 1,000 feet after the air locks were placed, the pressure was 8 to 10 pounds; for the second 1,000 feet it ran from 10 to 20 pounds, and for the rest of the tunnel from 20 to 27 pounds. At one point where bad ground was encountered, the pressure for about 12 feet of working distance was 37 pounds. The tunnel was completed as far as the location of the river shaft, and the sump under same was then built, after which the remaining 75 feet of tunnel and the two end bulkheads were constructed. This work was completed on the fourth day of April, 1905, and work was commenced on the river shaft at the crib. The entire time occupied in constructing the tunnel was nine and a half months from the first laying of brick, or an average of about 335 feet per month; but from June 14 to August 1, 1904, we only built 200 feet, being delayed by putting in the air locks and scarcity of brick, the latter coming very slowly at first. In the month of January, 1905, we built 454 feet 4 inches, during which we reached our maximum of one day's work, namely, 21 feet 2 inches, on January 23; 20 feet 3 inches, on January 16; and an even 20 feet on January 9. Our average during the month of January was 17 feet 6 inches per day.

The mining shifts consisted of one foreman, four miners and six muckers in each shift, also two drivers and one lock tender. The first mining shift excavated the top half of the tunnel to such distance from the end of the brickwork as the foreman considered could be bricked up in eight hours, and then took out as much of the bottom as they could in the remainder of their shift. Before commencing their excavation they had to strike the centers and put in the floor and track through the section of tunnel completed by the last shift of bricklayers.

The second mining shift completed the bottom and trimmed the circle and set in place the form for the invert. The reason that it requires more time to do the second half is on account of the men having to lift a large part of the material from three to five feet to place in the cars.

The bricklaying shift consisted of four bricklayers, six to eight helpers, two drivers and one lock tender. The number of brick to the foot being about 825; our average for the month of January of 17½ feet meant the laying of about 14,440 brick in eight hours, or 3,610 brick by each man. This means from 7 to 8 brick per man per minute, and when it is remembered that the keying up of the arch can only be done by one man, and that it ordinarily requires from 45 minutes to one hour to key up, it will be seen that in laying the bottom a much faster rate must be kept up. Besides this the centers have to be set, requiring from 20 to 30 minutes, which again operates as a delay. The maximum day's work of 21 feet 2 inches was laid up by the bricklayers in nine hours, and required 17,464 brick, or an average per man of 4,366.

The men outside the air lock were divided into two shifts of twelve hours. The day shift consisted of one engineer, one elevator man, one driver, and from two to four laborers. The night shift consisted of one engineer, one fireman, one driver and two laborers. The arrangement was as above until we found it necessary to make three shifts on top, leaving only the engineer, fireman and elevator man on twelve-hour shifts.

Mules were used for hauling the excavated material out of the tunnel to the air lock, from which it was taken on the elevator to the surface and again hauled by mules out on the dump. The month in which we made the best record was full of snow and sleet storms which impeded us in handling the material on the dump, and also in delivering materials into the tunnel. The latter work was done in the same manner as the removing of the earth, namely, by means of mules. The cars used in hauling earth were so made that the sides and ends being removed they were suitable for hauling brick. Also there were boxes provided in which the cement and sand were

mixed dry and thus sent into the tunnel on the cars, the mortar being wet and mixed in boxes at the face of the work. The mules changed shifts with the men, and went in and came out after a few trials as easily as any one. After one mule was killed by falling down the shaft, bars were put up to prevent such accidents, and the mules rode up and down like old miners. One mule only was obstinate as to going into the tunnel, and when he was once induced to go in, the air seemed to intoxicate him, and he ran down the tunnel and drove the men to the furthest limits, winning in the first round. This, together with his power of striking a blow with his feet, caused him to be christened "Terry McGovern," and he was used on top in future to haul out on the dump. The lintels over the shaft-house doors showed many marks of his hoofs, and his drivers were kept busy dodging him.

The only accidents that occurred in connection with the tunnel were two in number, one being when a driver fell and had his leg broken under a car, and the other when a laborer on top had two fingers crushed under the side of a car. Several men were affected by the bends, but none very seriously. The company provided facilities for hot baths for the men at the power house, also for coffee without limit. Medical attendance and examination of the air were also provided for. Every man who worked in compressed air had to be examined before he was employed to see that he was in a suitable physical condition to work in the tunnel.

Preliminary work on the river shaft was commenced on March 16, 1905, by taking tools and materials out to the crib, erecting derricks and setting up engines and boilers. The shaft was designed to be built inside of a steel cylinder having a diameter of 14 feet at the bottom, with a cutting edge extending 3 feet below the curb which held the brickwork. This cylinder was to be sunk to the bottom of the river through an opening in the crib, and then to be sunk through about 26 feet of earth to the top of the tunnel. Guide timbers were placed so as to keep this cylinder in a vertical position, the cylinder was then placed on a raft inside the crib and a watertight floor put in under the curb.

The raft was so constructed that it could be removed when the shaft had nearly reached the bottom of the crib by releasing the lines on one end and pulling the timbers out at the other. To prevent accidents, the lines holding the raft were attached to the heavy cross timbers of the crib at the top so as to support the shaft in case it leaked enough of water to overcome its buoyancy. Also a pulsometer was placed inside and hung from the derrick, steam for same being furnished through a pipe from the auxiliary boiler with hose connection. The steel shaft was made in sections and riveted together on the crib as the cylinder was sunk. The brickwork was started on the curb and was successfully built up for a height of about 16 feet, when the shaft was found to be so close to the bottom that the raft had to be removed in order to permit the shaft to enter the opening left for it in the bottom of the crib. With misplaced confidence in the pulsometer and the night watchmen, the shaft was left over night; the pulsometer acted badly, the watchmen thought they knew how to correct it, did not blow the whistle for assistance as they should, and neglected to use the buckets to bail out the shaft, which would have saved it, and the shaft filled with water and sank about 4 feet into the bottom of the river. It was in its proper location, however, and work was at once commenced to lower the water around it so that the steel cylinder could be extended by riveting on the top section. Several attempts to do this were unsuccessful, and finally the ports through which water entered the crib were blanketed and the inner chamber of the crib was pumped down low enough to permit the riveting to be done, after which it was easy to pump out the shaft. The watertight floor was then removed and the brickwork continued to the top of the lower cylinder. As the brickwork was built up, the shaft kept sinking into the clay, which was carefully excavated so as to keep the shaft plumb, and there was so little resistance by friction that without any external loading the shaft sank to the top of the tunnel, landing almost exactly in its proper location. The above described accident delayed the work about 30 days. The shaft was completed, including the underpinning, on June 19.

Meanwhile, from April 5 to May 11 and from June 14 to July 1, men were at work scraping and washing the tunnel, finishing by cleaning the shaft. The air locks were removed, buildings and plant were shipped away, the surface of the dump was graded and other

necessary work was done. The actual completion and acceptance of the tunnel and river shaft covered by the contract were made 95 days before the date set in the contract.

A short time before the tunnel was completed a pipe was driven at the edge of the crib on the engineer's center line to a depth such that it would show in the tunnel when we reached that distance, and it was duly encountered about one foot to the left of the center of the work. From this point we deflected the tunnel so as to bring the shaft connection in its proper location under the center of the crib.

In the month of December, 1904, we had our only difficulty in the work, having encountered a sand pocket on the night of the 16th. This was the only place in the tunnel where the roof required timbering, and was the cause of the increase of pressure to 37 pounds for three days, after which we returned to the normal pressure.

Previous to the letting of the contract, the engineers had taken borings for the entire length of the work, and our findings corresponded exactly with their reports, the material being a stiff blue clay through the entire length of the tunnel, except the sand pocket previously mentioned. This material was of such a character that semi-circular knives were used to cut it out.

ACETYLENE LIGHTING AND STORAGE*

Much has been written concerning the dangers of the use of acetylene, owing to the fact that it possesses the power of combining with metals, such as unalloyed copper, to form an explosive compound known as acetylide of copper, and to the fact that it will, under a pressure exceeding two atmospheres (gauge), separate into its component parts, carbon and hydrogen, such separation being attended by a great increase in volume, and, therefore, an explosion.

These statements are in the main true, but the common acceptance of them exaggerates their importance. For instance, it is stated that free acetylene under a pressure exceeding two atmospheres may be detonated by a slight shock or jar. The practice on one Canadian road with free acetylene stored in cylinders under a pressure of ten atmospheres has been attended with numerous explosions and quite a number of deaths. In each of these instances, however, we are unable to determine just how severe was the shock the cylinder received which caused the explosion. The uncertainty has led to the exclusion, by the Canadian Government, of any acetylene system using free compressed acetylene gas.

Assuming that the gas stored in such receivers were chemically pure acetylene, C_2H_2, there would still be another danger to be avoided. Should any part of these cylinders, owing to a wreck taking fire, be heated to 1,200° F., it would produce the ignition of the entire volume of gas within the cylinder, and the consequent explosion of the latter. Should ignition occur within the receiver containing free acetylene gas, this ignition is communicated immediately to the entire volume of gas, thereby causing an explosion of the most violent order. This ignition cannot be communicated through very fine apertures, such as burner orifices, or finely divided substances, such as asbestos, Kieselguhr, infusorial earth, or unglazed brick. These substances possess a porosity of 80 per cent., and the interstices are of such minute calibre that the transmission of flame through them is impossible. Researches have led to the use of acetone, a combustible organic liquid of high solvent power, which boils at 133° F., and at 60° possesses the power of absorbing twenty-five times its own volume of acetylene gas per atmosphere. Free acetylene gas possesses the largest known range of explosibility, or forms an explosive mixture with both the minimum and maximum admixture of air. When stored in acetone the gas carries with it a fractional percentage of acetone vapor. This vapor reduces the upper explosive limit about 16 per cent. Owing to the high price of asbestos, a mixture of infusorial earth, charcoal, oxide of zinc, and chloride of zinc is employed in France and Englind as a porous filling. This material forms a paste which, upon being dried, resembles chalk, which possesses a porosity, or cellular air space, of 80 per cent. In the United States the cylinders are packed with asbestos discs, the structure of which is obtained by building up the discs and cementing them together with silicate of soda. These discs have the same porosity as the French mixture, but possess the immense advantage over the latter of never breaking under shock or vibration.

*Abstract of a paper by R. E. Bruckner in *Stevens Institute Indicator*.

We thus have acetylene gas held in suspension or solution in the liquid acetone, this liquid being itself absorbed by the asbestos packing, and thoroughly saturating the latter. In so doing, the acetone itself is in very finely divided particles and offers the maximum absorption surface to the gas. The propagation of a flame or a shock through the entire mass is a physical impossibility. Experiments have shown that an electric spark may be passed through a charged cylinder and it will only produce local ignition.

The ordinary receiver used on railroads for Pintsch gas, and measuring 20 by 114 inches, contains, at a pressure of ten atmospheres, approximately 200 cubic feet of gas. A cylinder of the same size packed with asbestos and charged to about 40 per cent. of its volume with acetone, is capable of containing, at ten atmospheres, 2,000 cubic feet of acetylene gas. A lamp burning one and one-half cubic feet of acetylene gas is capable of delivering 2.3 times as much candle-power as a standard railroad lamp using any other illuminant and consuming from three and three-quarters to five cubic feet of gas, which makes it possible to store in one car at one charge sufficient gas to light the car two and a half months.

A charging plant is erected near the terminal or main railroad yard to be equipped. This consists of a generating apparatus, gasometer, or storage receiver for low-pressure gas, dryers and purifiers through which the low-pressure gas is passed to the compressor, which compresses the gas to ten atmospheres, into a storage receiver consisting of a series of cylinders filled as described before, wherein from 10,000 to 20,000 cubic feet of gas may be maintained. The generation is accomplished by means of a carbide to water generator. The gas produced from carbide manufactured in this country shows 98.67 per cent. pure acetylene gas, and as only traces of oxygen, sulphuretted hydrogen, and phosphoretted hydrogen are obtained, very little purification is necessary.

The compression is accomplished by means of a three-stage, water-jacketed compressor. Intermediate receivers, water-cooled, are provided between the stages. The distribution of the gas is accomplished by means of pipe lines leading to the various tracks and fitted with suitable connections.

Acetylene is known as a 50-candle-power gas, which means that when acetylene is burned in the most advantageous burner at the most advantageous rate, it will give approximately 50 candle-power per cubic foot per hour. The twin burner, in which two jets of acetylene are caused to impinge at an angle of 45° against each other, thereby flattening out into a flame at right angles to the plane of the jets is used. Each tip is so constructed that air is admitted in an annular ring around the issuing jet of gas, thereby preventing contact of the gas with the wall of the burner. These burners have proven perfectly successful and have been produced by various firms. Unfortunately they do not realize the high candle-power obtainable from a fish-tail burner. Their values may be summarized as follows:

Gas Consumption Per Hour	Actual Candle-Power	Candle-Power Per Cubic Foot
¼ cubic foot	6.12	20.36
½ cubic foot	16.01	32.68
¾ cubic foot	27.74	36.36
1 cubic foot	37.28	41.09

From the above it will be seen that the efficiency diminishes as the gas consumption is decreased, or the smaller sizes do not give a proportionate candle-power. Assuming the actual average candle-power of a 1-foot burner to be 40 candle-power, the relative efficiency of the various sizes would be as follows:

Consumption Per Hour	Relative Efficiency
1 cubic foot	100.0
¾ cubic foot	92.4
½ cubic foot	80.0
¼ cubic foot	61.2

In actual service conditions, two ¾-foot burners will give a higher candle-power than three ½-foot burners with the same consumption of gas.

The development of this art has been held back to a very great extent by the prohibitive price of carbide from which the gas is made. This product is controlled in the United States by a single company. Its cost of production is about $20 per ton and its selling prices ranges from $50, the price at which this company sells in Europe, to $90 to $100, the price at which it sells on the Pacific Coast. However, as the time limit of the patents is nearly run out, the possibility of a far cheaper illumination by means of acetylene gas may be anticipated in the near future.

COAL MINE VACUUM CLEANING

The diffusion of coal dust in the air has been a frequent cause of serious fires and explosions in English coal mines, and various devices have been employed to get rid of it. It having been proposed in the progress of parliamentary investigations to use the vacuum cleaning principle for the purpose, a special apparatus has been devised and successfully applied for this purpose. The device here shown is used in the Whitwood collieries, Normantown, England.

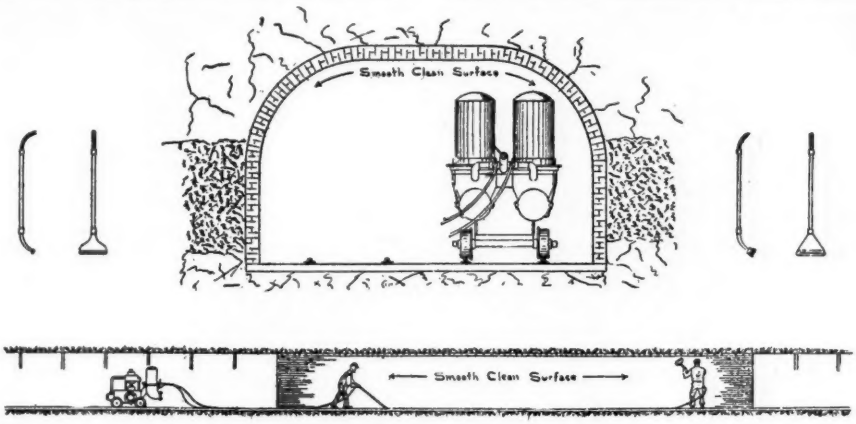


FIG. 1. VACUUM CLEANING IN A COAL MINE.

In this case the main roadways of the mine are prepared with concrete sides and roofs, whitewashed by a compressed air apparatus and kept free from dust by periodically going over it with the vacuum cleaner. It is claimed that watering is not only ineffective in cleaning away the fine coal dust which is the source of danger, but that after the water has dried up, which is inevitable in a warm mine, the dust is more friable than ever. The cost of operating the vacuum cleaner is said to be less than that of watering the sides and roof, and it is at the same time more efficient.

An explosion which occurred at Blackwell collieries commenced at a point in the interior of the mine on the main roadway in the intake air course, having been initiated by a shot which was bored to blow out an obstruction on the side of the roadway, but the force of which was liberated by a crack or joint of the strata, and only partly did its work. The dust was stirred up and ignited, and the blast extended along the roadways so far as the fine dust extended, but on reaching the inset, the walls of which had been cleaned and whitewashed, the explosion turned off at an angle, and followed along another main intake airway where there was dust, stopping when the fine dust was absent. The contention is that the light dust adhering to the tops, bottoms and sides of the timbers and supports of the mine, roof and all cracks and interstices, which can be approached within two inches, or where a yardstick can be inserted, can be sucked clean of inflammable dust, which may be removed from the mine and conveyed to the coke ovens or briquette plant.

The apparatus, driven by compressed air, will run on any ordinary roadway in the mine, and will pass wherever a pit tub will travel. Four or five nozzles, connected with flexible hose to the filters of the cleaner, will permit

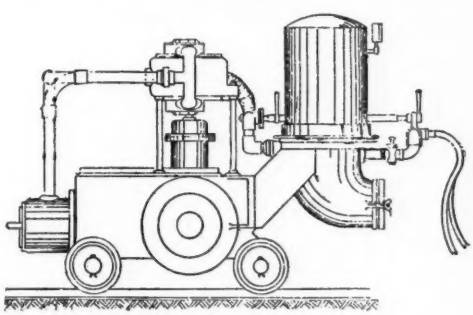


FIG. 2. THE APPARATUS.

of four or five men simultaneously collecting the dust. The filters being in duplicate, one may be cleaned and emptied while the other is in action.

Fig. 1 gives longitudinal and cross sections of the same roadway with the plant at work,

showing two operators cleaning smooth prepared zones. The plant is equally suited for removing the dust from timbering, walls, etc., of the unprepared roadways. The plant, which is mounted on a carriage which travels on the mine tramway, consists of a power-driven suction pump, connected to two filter collectors, from which lead flexible hose pipes. At the ends of these flexible pipes are attached suitable cleaning implements with which the operators remove the dust. The cleaning implements may be of various shapes and fitted with or without brushes, as shown in Fig. 1. The great rush of air into the cleaning implement, due to the high suction of the pump, causes every particle of dust over which the implement is passed to immediately enter it, and thence travel through the flexible hose to the filter collector, where it is retained. When one collector is full, the other is immediately put into operation by moving a lever, and the first is then emptied into a skip or bucket for removal from the mine. One operator can free from every particle of dust about 250 square yards of prepared zone surface per hour with reasonable diligence. The plant may be driven either by compressed air from the mine main or by spark-proof electric motor.

Fig. 2 shows the compressed-air driven plant as supplied to the Whitwood colliery, capable of employing six men. The power necessary to drive the machine is from 5-horsepower to 6-horsepower. The plant travels on the mine tramway, taking its power from points in the compressed-air main, and its over-all dimensions are 4 feet 4 inches high, 6 feet 3 inches long, and 3 feet 3 inches wide. Fig. 3 shows the compressed-air driven plant as supplied to the Courrières mine, France, of the same capacity as that illustrated in Fig. 2. The filter collectors are in this case mounted upon a separate trolley, and another trolley is provided for carrying a drum of compressed air supply pipe, so as to give greater range of action to the plant without the necessity of using extra lengths of hose for the operators. The above description is abstracted and the cuts are taken from *The Iron and Coal Trades Review,* London.

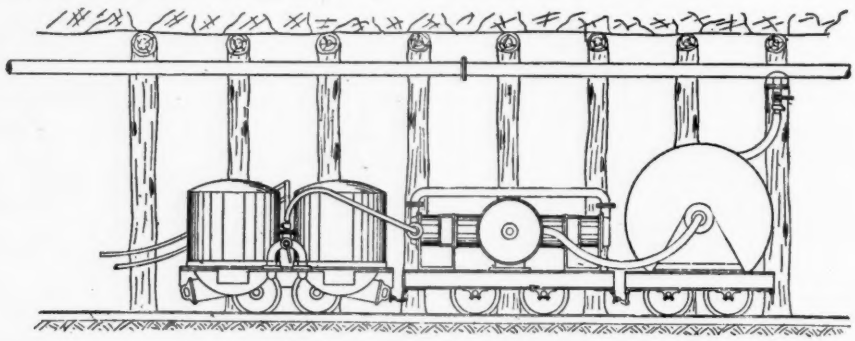


FIG. 3. APPARATUS USED IN FRANCE.

SLIMES AGITATION BY COMPRESSED AIR*

The use of compressed air for the agitation of slimes to assist in the solution of gold and silver in the cyanide process is widespread and its advantages are many and well known. Its economical application is, however, of utmost importance, and, as a result, many mechanical devices have been originated.

The Solis agitator is the invention of Mr. Benito Solis, metallurgist with the Negociacion Mineria Guadalupe de los Reyes, at which company's works in Northern Sinaloa, Mexico, it was perfected and where twelve have been in satisfactory use for over a year.

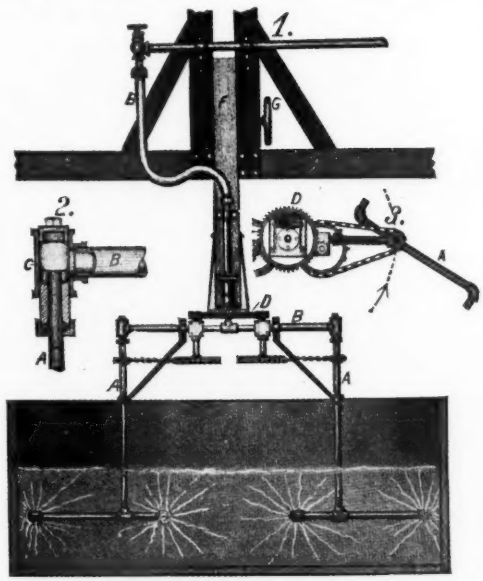
The metallurgical practice at the works is stamp-crushing, followed by pan-amalgamation of battery pulp and regrinding of tailings in tube mill with sands treated by percolation and slimes by agitation. The ore averages about $25 to the ton, with values about equally divided between gold and silver. About 70 per cent. of the values is recovered in the amalgamating pans. The slimes are reground to 200-mesh in a Krupp tube-mill of 4 feet diameter and 19 feet length.

Blow tubes, worked by Mexican men and boys, were formerly used in the agitation of

* Geo. G. Lyle in Mining Reporter. Slightly abridged.

the slimes, and the labor expense was a considerable item. With the use of the Solis agitator, a saving on labor costs of over $450 per year per tank has been effected, in addition to a saving in time of 24 hours—the slimes (75 tons of pulp and about 75 tons of solution) now being agitated but 72 hours instead of 96 hours as formerly.

The accompanying engraving shows the Solis agitator in operation. It runs by the impulse of the compressed air issuing from the nozzles. Depending into the tank are a pair of pipes A, formed at their lower ends with



SOLIS SLIMES AGITATOR.

tubular heads, each head ending in a pair of nozzles as shown in the plan view 3. The pipes A communicate with a transverse pipe B at their upper ends, the form of coupling being shown at 2. The pipe A, it will be observed, projects through a stuffing box and is formed with a collar C at its upper end which has ball bearing with the top of the stuffing box. Thus, the pipes A are permitted to rotate. Each pipe A is connected by chain and sprocket gearing with a pinion journaled on the pipe B and which meshes with a fixed gear D. The pipe B communicates with a flexible pipe E which is connected to the compressed air supply pipe. In operation the air is forced through the system of piping and out of the nozzles strikes the liquid in the tank and by reaction causes the pipes A to rotate. This motion is communicated to the pinions which, by reason of their engagement with the fixed gear D, cause the pipe B to rotate and revolve the pipes A. The pipe B and the fixed gear D are secured to a beam F which is arranged to slide in the main frame of the apparatus. A pinion operated by the hand-wheel G engages a rack on this beam and provides for vertical adjustment of the apparatus so as to move the pipes A to any desired depth in the tank.

The agitator not only renovates the contact surfaces and oxygenates the solution, but agitates in such a manner that it brings every particle of mineral in contact with the air and cyanide solution.

No claim is made that it can be used in the agitation of sands, although it has done good work when the slimes contained as high as 25 per cent. sands, *i. e.*, sands that will not pass 125-mesh.

The arms are made of ordinary gas piping, so that in case of breakage they may be easily replaced. In the ones in use the top horizontal pipe is 1½ inches in size, the uprights depending therefrom ¾ inch, and the immersed arms ½ inch—all sizes commonly found about mills.

About 3 h. p. is required in its operation in a tank of 31 feet diameter and 8 feet depth, when the arms are of a length of about 7 feet; it would, of course, cost no more for their operation in deeper tanks. It runs with as low an air pressure as 10 pounds, but 20 to 25 pounds insure easier running. It requires no attention after once started, so long as the compressed air is supplied.

COMPRESSED AIR IN THE BOILER SHOP

We are glad to reproduce here, somewhat shortened, an editorial from a recent issue of *The Boilermaker*. While there are two or three things in it which we perhaps would have said somewhat differently, it leads decidedly in the right direction. The article is in the way of announcement of a series of papers upon pneumatic tools, what they will do and how they should be operated and cared for:

From the way in which pneumatic tools are handled by the workmen in some boiler shops, it would appear to the casual observer that such appliances are of no more value than an ordinary sledge hammer or drift pin. While

no good mechanic would fail to realize that even the smallest and least important pneumatic tool is a delicate and expensive piece of machinery and would use it accordingly, yet when placed in the hands of an unskilled mechanic, the same tool is frequently subjected to various abuses which result in a loss of efficiency if not in the destruction of the tool.

While the economy and usefulness of pneumatic tools have been thoroughly demonstrated and have been, in fact, the cause of their extensive use, there are some points regarding the installation of the air compressor and system of piping which should not be forgotten. Progress in the use of compressed air has been rapid, and it was only about ten years ago that this form of power began to come into general use. At that time a simple air brake pump was frequently used for a compressor. Naturally, the cost and trouble of maintenance of such a crude form of compressor was considerable.

Compressed air systems are now installed in a variety of ways, some users preferring to use one or two very large units for compressing the air and then conveying the power through long, complicated pipe systems to the point where it is to be used. Of course, greater refinement in design can be obtained with the large compressors, and since the loss in transmitting power through long pipe lines amounts to very little if the lines are carefully inspected, and all leaks prevented, this is generally conceded to be the most economical installation. Compressors up to a capacity of 200 cubic feet of air per minute and a pressure of 100 pounds per square inch are usually single-cylinder, double-acting machines. Above a capacity of 200 cubic feet per minute and at higher pressures a two-stage compressor shows better economy. The duplex type with two simple cylinders, except for low air pressures, which do not warrant compounding, have nearly all been superseded by the two-stage type. A two-stage compressor compressing 100 cubic feet of free air per minute from the pressure of the atmosphere to 100 pounds gage pressure, shows a saving of about 35 per cent. over a single-stage compressor. The steam cylinders are generally compounded when the pressure at the throttle is 150 pounds per square inch or over.

An air compressor works with much greater economy when it can be run at moderate speed than when it is forced to high speed or beyond its normal capacity. Therefore, when installing a compressed air plant it is of the utmost importance to provide a large compressor. It is never safe to depend upon intermittent work in different parts of the shop to keep a moderate sized compressor working all the time. Sufficient capacity should be provided to supply the whole shop at the same time and to provide in addition to this a large margin for an increased demand.

After the proper compressor has been installed the economy of the plant may be greatly affected by the intelligent installation of the distributing pipe lines. Above all, the pipes should be of large size, since a large sized pipe gives a good storage capacity and prevents loss of power, due to friction of the air in the pipe. Provision should be made for a drainage of moisture in the pipe, and the arrangement of the pipe should be such that an accident or leak in one section will not tie up the whole plant. Some workmen seem to have the idea that since air is free to breathe it is not necessary to economize in the use of compressed air, but it should be remembered that it takes coal to compress the air, and even a small leak, say from a 1-16-inch hole, may mean the loss of a horsepower or more.

Moisture can be prevented in the pipe system by the effectual cooling of the air after compression. Likewise dirt and grit, which are extremely detrimental to delicate pneumatic tools, can be filtered from the air by the use of suitable screens. The air cylinders in the compressor should be lubricated with an oil which has a high flash point.

PROGRESS IN AERONAUTICS

The following is a portion of an address at the opening of the International Aeronautical Congress in New York by Professor Moore, chief of the Government Weather Bureau:

"Since the last International Aeronautical Congress, that at Milan in 1906, two practical solutions of the problem of aerial navigation have become established. Several dirigible balloons have been produced which are truly and effectively navigable, and a dynamic flying machine has been evolved which has flown many times, the maximum being twenty-four miles at a stretch. Moreover, there have been great advances in meteorology, so that we are now well on the way to the dominion of the air.

"The previous congresses chiefly discussed the means and methods that might be employed to achieve success; they pointed out the conjectured way; and now that success has come in a rudimental way at least, it remains to discuss further the evolution to be accomplished and the possible uses of balloons and flying machines. The paramount fact is that in order to be practically efficient the dirigible balloon should attain an inherent or 'proper' speed superior to that of ordinary winds. Scientific observations in France have shown that at Paris, at a height of say 300 feet above the Seine River, the probabilities of encountering a wind of less speed than thirty-two miles an hour are 798 in 1,000; that the chances of wind of less than twenty-eight miles an hour are 815 in 1,000, so that the possibilities are that a balloon possessing the latter speed could hold its own on 297 occasions or days of the year."

After telling of the work of foreign governments in this line, Mr. Moore said:

"In the United States the government has done practically nothing toward building dirigible balloons. This has been left to private initiative, and the only returns possible thus far are from public exhibitions. Mr. Stevens, Mr. Baldwin and Mr. Knabenshue have built and flown small and slow airships. They could have shown more speed if they had built larger ships, but this was beyond their means, for the Patrie is said to have cost $60,000. On the other hand, Mr. Wellman has built a very large and moderately fast airship in the daring project to reach the North Pole, and it is earnestly hoped that his third attempt next year will be crowned with success.

"It is thus seen that dirigible war balloons have been developed to an inherent speed of twenty-eight to thirty miles per hour. This is not likely to be exceeded very soon, for although the possible speed increases with the size, the danger and difficulties of handling such frail structures increase also. It is probable that the Zeppelin airship, 413 feet long and 38½ feet in diameter, is on the border of impracticability. The present speed may prove satisfactory on comparatively still days, but it remains to be ascertained by practice to what height balloons will have to ascend to be reasonably safe from gun fire and what winds will thus be encountered.

"The balloon possesses, however, two advantages over the flying machine. First, it can lift a greater proportionate surplus weight with increase of size. If this is not utilized for a more powerful motor projectiles may be taken up.

"The second advantage is that in a contest between the two (a flying machine and a balloon) the balloon by discharging ballast can rise vertically much faster than the flying machine, and the upper position confers great advantage both for attack and defense, as evidenced by all the contests between birds. The chief use in war, however, both of the dirigible balloon and of the flying machine will be in scouting and in directing artillery fire by use of wireless telegraphy. They will carry little surplus weight and their offensive operations will be limited, although occasionally lucky shots may prove decisive in their consequences, such as the destruction of a warship or of a powder magazine.

"Now that the air is to be navigated, the study of meteorology becomes more important than ever before.

"It is evident that the first application in aerial navigation will be to the art of war, and it is clear that its main usefulness will be in reconnoissance, for the loads which can be carried will be small. Balloons have not reached nearly their limit of speed and will always be comparatively slow. Flying machines begin with thirty-eight miles an hour and may attain in the future sixty to seventy-five miles an hour, with a radius of action perhaps 200 or 300 miles. Commercially very little is to be expected from either balloons or flying machines. Carrying freight is out of the question, and even profitable smuggling is doubtful. For passenger traffic the number will be so small and the cost so great that no competition is possible with existing modes of transit.

"Moreover, there will always be danger, but even before this has been minimized aerial navigation may serve in sport. This has already occurred with balloons and may be more pronounced with flying machines. The latter will be useful in exploration of otherwise inaccessible places, such as mountain tops, swamps or densely wooded regions. Balloons and flying machines will undoubtedly be used in carrying dispatches and even mail service may be attempted, but deliveries will be irregular. Upon the whole, now that success has come, we see that the conquest of the air has more limited practical uses than was imagined

when it was not known how that success was to be achieved, but it may develop new uses of its own and prove an important benefit to mankind."

PLYMPTON CHARACTERISTICS

Dr. Rossiter W. Raymond has contributed to a recent issue of *The Engineering and Mining Journal* an admirable "Tribute of Justice and Friendship" to the memory of the late Professor George Washington Plympton of Greater New York. Dr. Raymond is widely and justly celebrated for his faculty and facility of saying things as no one else could say them, things in themselves eminently worth the saying. His writings always furnish striking extracts when the whole cannot be appropriated, as note the following:

SCHOOL-MADE OR SELF-MADE?

This son's [Plympton's] early education was gained in a public school; but, like so many American boys of that period, he was obliged to leave his school-training incomplete, and give himself to a wage-earning occupation in a machine-shop. The notion still lingers here and there among us, that such enforced practice, interrupting, or altogether cutting off, theoretical instruction, is a good thing in itself. This is like the superstition that the endurance of hardship inures a man to further hardship. But we have found out in the field that white men could surpass in this respect the half-starved, half-frozen Indians of the plains and that in the war of the Rebellion recruits drawn from the comparatively comfortable life of the city could stand more of fatigue and deprivation than those who came from the strenuous training of farm-labor. The truth seems to be that foregoing severities of experience do not strengthen men, but simply, that they sift out the weaker men, so that, on the whole, the strongest only survive—though even these are not as strong as they might otherwise have been. We may say, in like manner, that deficiencies of early education and the necessity of self-help are not in themselves advantageous; but that those who defy and overcome them are likely to be men of strong, resolute character and high ambition. The fact that "self-made" men always try to give to their sons the early advantages which they could not command for themselves, is an additional proof of this proposition. Moreover, it is easy to over-estimate the scope of school-training. To some young men, it is invaluable, and the lack of it can never be made up. Others already endowed with the gift of intelligent study and the art of dealing with men, easily replace, during the years of practice, what they did not learn in school.

SLEIGHT OF HAND [MIND?] IN PEDAGOGY.

In his work as instructor at the Polytechnic, Professor Plympton exhibited in high degree his peculiar ability to stimulate and inspire his pupils. It may fairly be said that in many departments, and especially in those which concern rudimentary knowledge, the future usefulness of which is not immediately obvious to the young student, the teacher's greatest difficulty is to make the necessary initial drudgery interesting to beginners who do not appreciate its value. No pupil of his ever presented that difficulty to him. While he was still carrying his students through the alphabet of science, he began teaching them to spell. A happy instance of his method, accidentally made known to me, is the way in which he was accustomed, in connection with his course in physics, to induct his classes into the mysteries of legerdemain, of which quasi-scientific art he was himself an accomplished practitioner. Those who are acquainted with the history of this art need not be told that such masters as Houdin made use of the latest scientific discoveries in magnetism, electricity, etc., for the working of their seeming miracles, and that the marvels not thus to be accounted for were tricks, performed by skilful hands in the presence of untrained observers. Indeed, when I note how many honest, good, even scientific people, are continually deluded by such "occult" performances, I am almost ready to declare that instruction in legerdemain ought to be a part of every course in physical science. At all events, Professor Plympton made it incidentally a part of his course; and I remember with pleasure the account he once gave me of a couple of his students who, upon their graduation, made a journey to India, and, being amply furnished with money, made it their business to see, at any cost, the best that Indian magicians had to show; and who, after their return, reported to him that they had witnessed absolutely nothing which they were not able, through the previous instruction received from him, to detect at once as a mere trick—and, in most cases, a very clumsy one. Plympton, in telling me of this incident, connected it with the his-

toric encounter between Houdin and the magicians of the East, in which the French expert not only divined and reproduced all their miracles, but performed others which they could not copy or explain.

COULD NOT GET ANGRY.

The great secret of this extraordinary administrative success was undoubtedly the man's invariable mood of courtesy, sympathy and self-control. Anger always clouds the judgment, and complicates the situation. Now, I never saw Professor Plympton angry—not even when, as the head of the Brooklyn Subway Commission, he was scurriously attacked; and I, as his colleague, was righteously angry for him! Nobody at Cooper Union, so far as I can learn (and my experience is corroborated by the testimony of those who saw him every night for some thirty years of his service there), ever saw him angry. And, most wonderful of all, he was equally gentle and equable at home. His son, a man of mature age, says *he* never saw him angry! I emphasize this feature of his character, not by way of preaching or eulogy, but from the standpoint of an engineer, as an illustration, almost uniqe in my observation, of the saving of energy, the avoidance of "waste motion" through intellectual error, and the increased efficiency and durability of work and influence, through the maintenance of an absolutely constant temperature of mind and heart. Those of us who need to be excited before we can "do our best" are not really ever doing our best. The feverish is not the most forcible. The western phrase, "He did his *level* best," has a deep philosophy in it; for it characterizes the man upon whose strength we can always place our reliance—the man who is always "in good form" for his task, and ready to discharge it with elastic readiness and complete command of its requirements.

SHUNTING THE CRANKS.

I must mention here, as an additional item in the already astonishing catalogue of his numerous occupations, one of his many functions as director of the Cooper Union—a function officially unrequired and unrecorded, and voluntarily assumed. Namely, he used to receive, hear and advise all sorts of inventors and "cranks," presenting more or less revolutionary novelties in scientific theory or practice. Such folks not only drifted to him; they were also referred to him by those who wished to get rid of them. Discoverers of devices for perpetual motion, squarers of the circle, etc., etc., as well as the inventors of devices less clearly, though not less really, absurd, inflicted themselves upon him. From the stories of such experiences which he told me from time to time, I infer that perhaps nobody ever surpassed him in the patient courtesy and secret amusement with which he received and enlightened such crude enthusiasts. The only precedent known to me is that of the Oxford mathematician, Professor De Morgan, whose contributions to "Notes and Queries" (published after his death in that delicious, and now scarce, book, "A Budget of Paradoxes") show what delight he felt in dealing with the queer propounders of eccentric doctrines. The difference is, that Plympton never published the crude notions of his visitors, together with his own witty refutations of them, but simply tried, as a friend, to correct their errors, and guide them to more thorough study of principles.

A DAY'S WORK.

I can remember a time when he used to leave home at 7.30 A. M.; go by horse-car to his duty at the Brooklyn Polytechnic; thence to the Long Island College; thence to his editorial work at Van Nostrand's, and finally to his night's service at the Cooper Union, after which he reached home between 10 and 11 P. M., to repeat the same program on the following day. On Saturday night, however, he permitted himself to break through this rigid routine; and in the memorable, happy days when the *Century* still had its home in 15th street, he and I used to enjoy, that night, an hour of relaxation, before returning together to Brooklyn. As a general rule, he could be found, during this hour, playing billiards—a sign, as I have always thought, of the need, to a mind long strained, of radical and restful change. Yet, on the journey home, much longer in those days than now, he was as freshly appreciative and suggestive as if nothing had happened during the week to make him tired.

Apart from his native gifts, the chief factor of his enduring, versatile intellectual vigor was, as I have indicated, his genial temperament. But, on the physical side, his sound health and regular, temperate habits must be taken into account. One of the habits which played no small part in the maintenance of his powers was that of spending the summer vacation in complete rest and out-door recreation.

AIR PIPE LINE CAPACITIES

South African Mines, printed at Johannesburg, South Africa, is working faithfully for the quickening and betterment of compressed air practice "on the Rand." The pressures employed are not high at the compressors, and at the drills much too low, the result apparently of using pipes of insufficient capacity. The article here reprinted from a recent issue should do good if such things are heeded in that field.

The continual reference by *South African Mines* to the low air pressures prevailing on the Rand appears to be having an effect, as our leading mining and mechanical engineers are beginning to recognize that an underground pressure of 35 to 55 pounds does exist, even though engine-room air charts record 70 to 80 pounds at the surface. The engineering staffs in the town offices, as well as the managers and engineers on the mines, are not only willing to admit the criticisms are justified, but one after another they are making attempts to remedy the evil and save the Rand the £100,000 annually wasted because the underground air pipe lines used are too small for the service required of them.

The greatest power loss on the average mine is unquestionably due to underground air lines being too small, and because so little is really known on the Rand regarding the best size air lines for a certain work, it may not be amiss to give the latest information on the subject. The following tables giving the carrying capacities of various size pipes for various distances are based on D'Arcy's formulæ, and have been proved correct in practice. Decimal points and fractions have been omitted wherever possible, and it has further appeared desirable to suffer a total loss in pressure of about 12 pounds, 3 pounds being accounted for in the air line going down the shaft, 3 pounds in the air lines along the drives and cross-cuts, and 3 pounds in the stopes, with a further loss of about 3 pounds due to bent pipes, short turns, valves, tees, elbows, crosses, etc. Delivering air at the engine-room receiver at 75 pounds, which is the practice here to-day, will then mean getting 63 pounds at the working faces, as against the present 35 to 55 pounds. The best practice does not admit of a total loss greater than 5 pounds, but as 20 to 30 pounds is the present loss in pressure, and wonders can not be worked overnight, let us split the difference and suffer the 12 pounds loss until such times as we realize that this nominal loss is insufferable.

SHAFT AIR LINES.

Assuming the initial air pressure in the engine-room is 75 pounds to the square inch, and that the loss in pressure due to pipe friction is not greater than 3 pounds, we find that a given size pipe line has the following capacity for various lengths:

6-inch pipe line,

1,000 ft.	long is large enough for only		19	large drills
2,000 ft.	"	"	14	"
3,000 ft.	"	"	12	"
4,000 ft.	"	"	10	"

7-inch pipe line,

1,000 ft.	long is large enough for only		28	large drills
2,000 ft.	"	"	22	"
3,000 ft.	"	"	18	"
4,000 ft.	"	"	16	"

8-inch pipe line,

1,000 ft.	long is large enough for only		39	large drills
2,000 ft.	"	"	31	"
3,000 ft.	"	"	25	"
4,000 ft.	"	"	22	"

9-inch pipe line,

1,000 ft.	long is large enough for only		54	large drills
2,000 ft.	"	"	41	"
3,000 ft.	"	"	34	"
4,000 ft.	"	"	29	"

10-inch pipe line,

1,000 ft.	long is large enough for only		68	large drills
2,000 ft.	"	"	54	"
3,000 ft.	"	"	45	"
4,000 ft.	"	"	38	"

12-inch pipe line,

1,000 ft.	long is large enough for only		107	large drills
2,000 ft.	"	"	85	"
3,000 ft.	"	"	71	"
4,000 ft.	"	"	61	"

DRIVE AIR LINES.

Assuming the air pressure at the station underground is 70 pounds, and that a loss of 3 pounds pressure in the drives is not to be exceeded, we have the following capacities for various size pipes for various lengths:

2½-inch pipe line,

500 ft.	long is large enough for only		3	large drills
1,000 ft.	"	"	2	"
1,500 ft.	"	"	1⅜	"
2,000 ft.	"	"	1½	"

3-inch pipe line,

500 ft.	long is large enough for only		4½	large drills
1,000 ft.	"	"	3⅛	"
1,500 ft.	"	"	2½	"
2,000 ft.	"	"	2⅛	"

4-inch pipe line,

500 ft.	long is large enough for only		10	large drills
1,000 ft.	"	"	7	"
1,500 ft.	"	"	6	"
2,000 ft.	"	"	5	"

5-inch pipe line,

500 ft.	long is large enough for only		18	large drills
1,000 ft.	"	"	13	"
1,500 ft.	"	"	10	"
2,000 ft.	"	"	9	"

STOPE AIR LINES.

Assuming the air pressure is 65 pounds in the drive and that a further loss of 3 pounds pressure in the stopes is not to be exceeded,

we have the following capacities for the various size pipes and for lengths up to 300 feet:

1½-inch pipe line,				
100 ft. long is large enough for only			1½	large drills
200 ft.	"	"	1	"
300 ft.	"	"	1	"
2-inch pipe line,				
100 ft. long is large enough for only			3½	large drills
200 ft.	"	"	2½	"
300 ft.	"	"	2	"
2½-inch pipe line,				
100 ft. long is large enough for only			6	large drills
200 ft.	"	"	4½	"
300 ft.	"	"	3½	"
3-inch pipe line,				
100 ft. long is large enough for only			10	large drills
200 ft.	"	"	7	"
300 ft.	"	"	6	"

With the usual engine-room air pressure of 75 pounds, and adhering strictly to the dimensions and capacities given, there will be no excuse for an air pressure at the working faces of less than 60 to 65 pounds—there will be no excuse for the miner not getting in four 6-foot holes before 12 o'clock, and there will be no excuse for the underground official who does not insist on at least two more holes being drilled before blasting time. Furthermore, the air compressor will work a shorter time, because, instead of compressing air for five to six hours to drill four holes per rock-drill, it will only have to work 75 per cent. of this time for the same tonnage broken.

To show what a deviation from the figures in the foregoing tables means, the following remarks are appended:

Increasing Length of Pipe Line by Two, i. e., doubling any length given in the tables and operating off it the same number of drills, doubles the friction loss and makes it 6 pounds instead of 3 pounds.

Doubling the Number of Drills that a given size and length of pipe line is rated for in the tables, quadruples the friction loss and makes it 12 pounds instead of only 3 pounds.

Lengthening a Given Pipe Line or Increasing the Number of Drills over the figures given in the tables, increases the initial friction loss of 12 pounds to 15 pounds in one case, and 21 pounds in the other. This is to be avoided.

HOW COMPRESSED AIR MAY DESTROY SEA WALLS

Mr. O. Fraser, superintendent and ex-government inspector of works, writes to *Engineering News* from Port Colborne, Canada, an interesting letter having to do with concrete sea walls and the conditions under which they are disintegrated by wave action. He says that when the 1-2-3 mixture is used there is no trouble. In one large foundation the crushed stone was abandoned and river gravel was used, 1½ of gravel to 3 of coarse sand. The results were incomparable piers and quays with a face as if it were polished glass.

He says further:

Let those who are building sea and quay walls avoid crushed stone as they would avoid the mischief, and adopt gravel concrete to the proportions given; that is, up to low water or neap tide levels; then adopt 1-2-3. To reduce the cost from low-water level up to coping, use the crushed stone there with 35 per cent. of one-man stone rubble displacers. Then you have a conglomerate, a solid mass of monolithic concrete. Let the rubble displacers be kept back from the face of the form one foot and that solid foot of concrete be well rammed and faced up with a trowel.

I have found that in building these quays and sea walls there was no disintegration, simply for the reason that the face was smooth as glass and as solid as concrete can be made. On building with 1-2-4, which seems to be generally adopted under water, I distinctly say it is utterly impossible to build with these proportions and at the same time use crushed stone. When building, the wall will be in the condition as described, full of holes under water that cannot be pointed, and the portion above water is always damp and will not hold the pointing. And by some it is called disintegration through chemical action; by others it is thought to be caused by ice abrasion, and they are nearer the mark. What can be expected when great blocks of ice come smash on to a face of 1-2-4 concrete? It is not conceivable that two parts of sand will fill the voids of four parts of crushed stone.

The half of the whole mass is full of air. A storm coming on from any direction of the seas is always worse between high and low water, as generally at high water the storm abates. The storm being at its worst at the top portion of the underwater concrete and the bottom portion of the top concrete, it is there where the destruction begins. The top portion may be anything from 12 feet to 20 feet, according to location. Just take that body of water 12 to 20 feet, backed up by the full weight and force of the ocean, coming on with a rush just like a demon, and again receding back 100 feet and coming on with crested

waves from 20 to 30 to 50 feet in height, with that snarled crested curve coming on and dashing on to the wall surface that has holes and contains in its body a full half of air. This air is locked in and becomes compressed. That something has to go is certain. Explosions and a series of explosions take place. This goes on from day to day, week to week, month to month and maybe from year to year until it is discovered that the wall is getting cut up, and then it is called disintegration when it should be called air abrasion or compressed air explosions.

The remedy is as follows: For walls under water to any depth, use gravel concrete; use sea water; let the proportions be 4½ cubic feet to one bag of cement; bring up your underwater concrete 2 feet above low water level. Mark this particularly, as the density of your concrete depends on it. Use the full volume of water to one bag; if in dry, hot weather, 4 to 4½ ordinary pails of water, if damp, 3 to 3½. Do not be afraid to give the full volume of water, because when full it cannot receive any more if your concrete has not the full volume; then when you deposit it water is just like air. There can be no voids. It will rush in to fill that void and in its course rushing in it washes away the cement (which becomes free lime). Concrete is just like the hungry man. Give him a full meal, give him a good skinful, and he cannot take any more. This volume of water is for density, solidity, and to produce a face such as no man by any manner or manipulation can produce. With no lodgment for air, your wall will stand for many generations and we will hear no more about disintegration.

GASES OF THE COAL MINES

At a recent meeting of the Midland Branch of the National Association of Colliery Engineers, held at Nottingham, Eng., Professor F. Clowes discoursed upon the above topic. We present a brief abstract:

While chemists use the word gas, miners generally call the gases of the mines "damp" —choke-damp, fire-damp and after-damp. As the gases can be liquefied, they are really vapors, and "damp" is all right for them. The compressibility of the gases has an important bearing upon the damps of the mine. When the barometer is low, indicating a low pressure of the air, miners must be on their guard against the gases, which are then apt to be released. Certain liquids have a slow process of mingling with each other, but all gases mix spontaneously and rapidly. The light, inflammable gases which escape in the roof of the workings have a tendency to mix with the air. The heavier gases on the floor will do the same, and the whole will in time produce a uniform mixture. This mixing is accelerated by the rapid ventilating currents which all collieries have to maintain.

Gases differ in their affinities for and solubility in water. The gases common to a mine are generally only slightly soluble. Water containing caustic soda will absorb carbonic acid gas, and use is made of this in a rescue apparatus for a man to strap on his back. The carbonic acid in the wearer's breath is absorbed by the caustic soda solution and the air is so far purified.

Ventilation is carried on upon such an extensive scale in coal mines that there should be little difference in the air within and without the mine, except for the causes operative in the mine itself. Breathing changes the oxygen of the air to carbonic acid and this to a considerable extent. Fresh air has oxygen, 20.81 per cent.; nitrogen, 79.15; carbonic acid, 0.04, or about that. Breathed or expired air may show oxygen 16.03, instead of 20.81, but the carbonic acid has been increased perhaps a hundredfold by respiration. Every forge below ground also is responsible for an increase of this gas.

It has been found necessary to adopt systems of ventilation, or air renewal, in other places. In the tube railways the air is much more rapidly vitiated and their engineers have taken their lesson from the mines and have adopted similar means for ventilation.

When the oxygen of the air is reduced to 16 per cent., no ordinary flame, as a candle, will burn in it; hydrogen, however, will burn in air which contains only about one-quarter as much oxygen, and coal gas, which consists largely of hydrogen, will burn under similar conditions. "Gob" fires start in the mines from the heating of small refuse which has been neglected. This heating is caused entirely by the oxygen in the air which the coal slowly absorbs, and when the fire is once started it spreads rapidly around.

CHOKE DAMP.

Carbonic acid in the mine escapes directly from the coal and its weight causes it to settle

on the floor. It is necessary to search for it in holes in the floor where it is not swept away by the ventilating currents. Carbonic acid is not poisonous. If you try to breathe it unmixed with air your lungs refuse, which gives rise to the name "choke-damp."

CARBONIC OXIDE.

Carbonic oxide, sometimes mistaken for carbonic acid, is extremely poisonous, but it is not produced from the coal. If an explosion of fire-damp takes place with an insufficient quantity of air, carbonic oxide is almost invariably produced, and when explorers go down a small portion absorbed produces fatal results. Unfortunately it is a gas not easily tested for in mines, and the only wise precaution, if there is any suspicion of its presence, is the protection of a breathing apparatus, which is an absolute safeguard in this case. Blast-powder and nitro-cotton produce carbonic oxide, but good active ventilation clears it away quickly.

FIRE DAMP.

Fire damp is not a poisonous gas; one cannot live in it because of the lack of oxygen. In some mines it comes out from the coal as pure marsh gas, but far more generally it is mixed with nitrogen and carbonic acid. This gas is not explosive, and only becomes so when mixed with air in certain proportions. It explodes with the greatest violence when there is 10 per cent. of it in the air, and the range of danger is between 6 per cent. and 16 per cent., beyond either of which explosion does not occur, while fire may. It is always necessary to detect the presence of this gas, because if it increase above the 6 per cent. explosion is possible at once. Lower mixtures also become explosive if coal dust is present in considerable volume. Coal dust, indeed, of a fine character and mixed with air only can carry an explosion to a considerable distance.

The above is abstracted from a report of the address in *The Iron and Coal Trades Review.*

THE AIR LIFT FOR MINE PUMPING

Mr. Joseph H. Hart contributes to a recent issue of the Mining World an interesting article upon "The Pumping Machinery Employed in Mining." After speaking of the wastefulness and other objectionable features of steam pumps as employed in mines and saying a good word for centrifugal pumps under suitable conditions, the writer proceeds as follows:

In addition to the types described above, there are in existence to-day a number of pumps known technically as the air-lift system. That these pumps are not in more general use in mining is a matter of considerable surprise. In ordinary pumping installations where water must be drawn from a number of different sources simultaneously, the efficiency and availability of these pumps is unquestioned. The air-lift system of pumping is based upon the utilization of compressed air for the conveyance of the water. It involves the installation of an air compressor and a reservoir therefor. In the majority of mining operations compressed air is an absolute necessity for the drills, and the presence of an air compressor tends to simplify the problem and will further increase the available efficiency in the whole process. Again, in caisson work compressed air is absolutely necessary under all circumstances. Under conditions where air compressors must be at hand, by increasing the unit slightly the extra unit for operating the air-lift pump is saved. Moreover, with the installation of a single large operating unit, in preference to several small units, the saving benefits the entire plant, and such an operating unit invariably becomes more efficient as the cost per unit is diminished per unit of power capacity of the machine.

Given an air compressor, the operation of the pump itself is extremely simple. It consists merely in sinking a well to a slightly lower depth to obtain the pressure head with which to operate. A pipe is lowered from the pump into this well and compressed air is driven from it through the pipe and rises through the water into another pipe. As it rises in this pipe, the air expands, and by this action and its upward motion the water receives an upward impulse which is sufficient to carry it considerably above its former level. In ordinary practice the height to which water can be elevated by this process seldom exceeds one and one-half times that to which the water falls in the well without reversal occurring. If the pipe which carries the air and water upward is tapped and more compressed air injected, the process becomes continuous, and the water can be lifted to any height. This latter procedure has seldom, if ever, been carried out in mines, and such installations as are in existence are operated so as to make this method for carrying air comparatively in-

efficient, which limits the application to the distance mentioned.

The air-lift process is much more efficient, however, than the ordinary surface pump. It possesses all the advantages of the ordinary single or multiple turbine pump. The power comes from compressed air in the production of which a fairly high efficiency may be maintained, or at least much greater than that in the operation of ordinary surface pumps. Further, the fact that the air compressor is indispensable under any circumstances practically settles the matter. Turbine pumps generally require a separate steam unit for their operation or for the production of the electrical energy to operate them with, and with the saving of separate units which is involved there is brought into the problem the first cost of installation as well as cost of maintenance.

In action, this system compares very favorably with the centrifugal pump. In ordinary action, especially when the service is severe, enormous friction marks the centrifugal type of pumps. The advantages of the centrifugal pump, incident to the elimination of valves and the possibility of carrying considerable obstructions and detritus with the water throughout its circuit, is present in the air-lift system in its simple form. Many adaptations of the latter type are used for increased efficiency, and in many cases the air is first used in some form of cylinder similar to the ordinary pump for giving the water the upward momentum. The exhaust from this cylinder is then used to further accentuate the upward velocity of the water. The utilization of this type is not possible for the conveyance of water carrying many impurities and solid particles. It has, however, an increased efficiency as compared with an ordinary air-lift system. This efficiency is in the pump proper, and its best operation is dependent upon the power supplied. Both of these factors must be considered separately as well as in their interrelation before an adequate decision can be rendered in regard to any installation.

With regard to power production, the fact that compressed air must be used in other developments of mines is almost conclusive evidence for its utilization in this development. Given a supply of compressed air, its utilization for pumping purposes is best accomplished in the simplest and most direct fashion.

POWER FOR THE SHAVINGS EXHAUST FAN

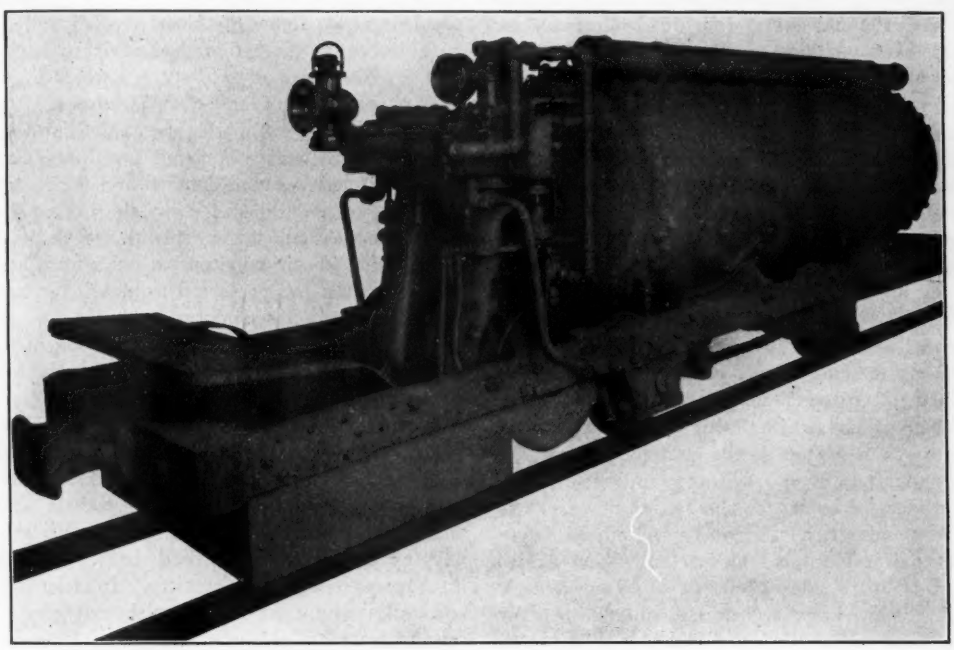
It seems to be a fact that the simple principles of pneumatics involved in the operation of the exhaust fan are not exactly clear in the minds of a great majority of the men who are familiar with the operation of this useful device. It should be clear from the start that the fan can exert force only in one direction, and that one away from itself. We speak of the pull of the fan as though thin air could be drawn or pulled like a rope, while the fact in the case is that it can only be pushed. Suction is not the pulling of the fan or of the plunger in the cylinder, but the forcible shoving away of the air on the other side, in order to create a partial vacuum, into which the air is in turn pushed by the atmospheric pressure outside. It is for this reason that it is impossible to create any great pressure with an exhaust fan, even if it were possible for the fan to produce a perfect and continuing vacuum, as the outside pressure is something less than 15 pounds per square inch, depending upon altitude. Reasoning from these known facts, it will become apparent why an exhaust pipe loaded with shavings consumes more power at the fan than one running empty.

Let us suppose that a fan is running empty, and all at once the pipe is given a normal load of shavings. The result will be that no extra power will be required until the shavings reach the fan, but at that instant the effect will be noticeable in the behavior of the belt, which will show that it is carrying a load instead of running idle. Now let us stuff the inlet to the pipes with an overload of refuse, and we shall see the common symptoms of an overloaded belt; it will squeak and slip, and perhaps slide off the fan pulley and rub over against the castings of the machine, while the fan will slow down, and if the cramming is continued long enough, the pressure will fall below the lifting capacity and the pipes will clog. Need I go further and explain that after the refuse leaves the fan it has to be forced to the outlet of the pipe and discharged in order to make way for that which is following? Must I say that shavings, chips and sawdust are heavier than air, and that it takes more power to drive them along a pipe than it does the empty air?

Just how much more power it takes to carry the load of an exhaust fan depends, of course,

upon the load; and the load depends not only upon the number and kinds of machines to be handled, but upon the kind of wood being worked, the length and direction of the outlet and the length and direction of the inlets. No one could say with authority just how much more power it would take to run a loaded fan than an empty one, unless it would be the designer of the fan, and he to prescribe the conditions.—Charles Cloukey in *The Wood Worker.*

an hour, and a charge of air is sufficient for a mile and return. The maximum pressure in the storage tank is 1,000 pounds and a pressure reducer maintains 100 pounds as the working pressure. The engine is, of course, reversible, although the link motion is not used, and there are air brakes and all the necessary fittings for handy and safe operation. A chain drive connects the engine shaft with the axles.



A Narrow-Gage Compressed Air Tunnel Locomotive.

A NARROW GAGE COMPRESSED AIR LOCOMOTIVE

The half-tone shows a locomotive designed by Mr. E. A. Rix of San Francisco, who has done much to promote the use of compressed air, especially by novel and original applications of it. Three of these locomotives have been made for a tunnel over three miles long which is being built near San Francisco. The tunnel is being driven from each end and in both directions from a central shaft, thus providing work for the three locomotives. The gage of the locomotive is 20-inch and its weight about 7,000 pounds. It passes through an opening 34 inches wide and 50 inches high. It will haul 12 tons at a speed of 6 or 7 miles

THE POLICY OF SECRECY

The following is an abstract of a portion of a paper by Mr. James Douglas presented at the meeting of the American Institute of Mining Engineers:

Technical science has progressed of late with unwonted speed through the co-operation of many workers, and this co-operation has been made possible by the publication and exchange of ideas and experiences in the technical and scientific journals. Would not our progress be even more rapid and thorough if all barriers of secrecy were broken down, and every encouragement were given to our technical workers to describe, in print and by

conference, their notions and their actual experiments?

We know that very few technical papers issue from certain establishments; that on their officials silence is imposed; and that to these works inquisitive visitors are politely but peremptorily refused admission. There are not many such, but some of them are and have been very successful. But suppose that in imitation of their practice and regulations all were tempted to adopt it, what a sudden paralysis of industry would follow! Our secretaries would find it difficult to fill even their shrunken volumes of transactions with papers worth printing; our students would have to content themselves with the antiquated learning which their professors could supply. Every manufacturer and smelter would be obliged to bribe his neighbor's workmen and tempt away his neighbor's superintendents for information. Before long, the very works which now find it so profitable, or who think they do, to tap their friend's stock of knowledge and experience, and give nothing in return, would be driven in upon their own resources, and would undoubtedly then find them not so complete as they imagine.

The spirit of intellectual freedom in our professions is too strong and too widespread to submit to such a tyranny, and before such darkness of ignorance had settled down to our great industries, the most pronounced advocates of secrecy would feel and acknowledge the ultimate consequences of concealment. They may have secrets as valuable as Sir Henry's method of making plate glass and bronze powder, which it may pay them to conceal from their competitors, so long as they are admitted freely to their competitor's open shops; but even this is doubtful. For the spirit of secrecy is intimately allied with the spirit of suspicion and distrust; and the mind which is always suspecting is closed tight against the admission of fresh and fair impressions. Progress, therefore, ceases.

The iron and steel works of Europe have not kept pace with ours in size and production, but the iron-masters of Great Britain and Germany, in coke-making and in blast-furnace economies and in steel-making processes, have been our teachers. Nor have they been shy of communicating their improvements, or, through jealousy of our success, slow in adopting ours. No nobler monument of international comity in thought and experience exists than the seventy volumes of the *Proceedings of the Iron and Steel Institute.* And with few exceptions the iron and steel works of England, Scotland, Germany and France are open to any accredited worker in the same domain.

Yet before England was conspicuous as a maker of iron, she was famous the world over for her copper and tin production. But, between self-conceit and the inbred habits of trade-secrecy, her copper-smelting industry has fallen from its high estate. And it is not accidental, but linked as closely as any effect with its cause, that this decline is in great part the result of habits of secrecy which grew with the growth of age. At Swansea, every gate to the smelting works is guarded, and as a result it has been as difficult for thought to escape out as for suggestions to find their way in. Swansea should still enjoy the leadership which her skilled labor, splendid coal, and commanding maritime situation put within her reach; but she has preferred to gloat over her secrets behind closed doors rather than go out into the world in search of new business as well as technical methods, while also inviting the world to enter and exchange ideas with her. What is the consequence? New Zealand copper comes to the United States to be refined, notwithstanding that the first practical application of electrolysis to metals was made by Elkinton in England, and the Vivians adopted the Manhes method before Farrel introduced it into this country. In scientific and technical matters, the banishment of deceit, mystery and jealousy and the freest admission of daylight by means of the unreserved diffusion of information through the press and personal intercourse, will instil into the whole body of workers a feeling of healthy rivalry, which, while stimulating their mental activity, will correspondingly benefit the financial interests of their employers.

AIR REQUIRED FOR VENTILATION

Under the general conditons of outdoor air, namely 70 degrees temperature and 70 per cent. of complete saturation, an average adult man, when sitting at rest in an audience, makes 16 respirations per minute of 30 cubic inches each, or 480 cubic inches per minute. With 70 degrees temperature and 70 per cent. humidity, the air thus inhaled will consist of about

one-fifth oxygen and four-fifths nitrogen, together with about one-seventh of 10 per cent. of aqueous vapor, and four one-hundredths of a per cent. of carbonic acid. By the process of respiration the air will, when exhaled, be found to have lost about one-fifth of its oxygen by the formation of carbonic acid, which will have increased about one hundred fold, thus forming about 4 per cent., while the water vapor will form about 5 per cent. of the volume. In addition, the exhaled air will have warmed from 70 degrees to 90 degrees, and, notwithstanding the increased proportion of carbonic acid—which is about one and one-half times heavier than air—will, owing to the increase of temperature and the levity of the water vapor, be about 3 per cent. lighter than when inhaled. Thus it will be seen that this vitiated air will not fall to the ground, as has often been presumed, but will naturally rise above the level of the breathing line, and the carbonic acid will immediately diffuse itself into the surrounding air. In addition to the carbonic acid exhaled in the process of respiration, a small amount is given off by the skin. Furthermore, one and one-half to two and one-half pounds of water are evaporated daily from the surface of the skin of a person in still life. If the air supply at 70 degrees is assumed to have a humidity of 70 per cent. and to be saturated when it leaves the body at a higher temperature, then at least four cubic feet of air per minute will be required to carry away this vapor.

Taking into consideration these various factors, it becomes evident that at least four and one-half cubic feet of fresh air will be required per minute for respiration, and for the absorption of moisture and dilution of carbonic acid gas from the skin. This, however, is only on the assumption that any given quantity of fresh air, having fulfilled its office, is immediately removed without contamination of the surrounding atmosphere; but this condition is impossible, for the spent air from the lungs, containing about 400 parts of carbonic acid gas in 10,000, is immediately diffused in the atmosphere. The carbonic acid does not fall to the floor as a separate gas, but is intimately mixed with the air, and equally distributed throughout the apartment.

It must, then, be evident that ventilation is in effect but the process of dilution and that when the vitiation to be maintained in the apartments is decided, the necessary constant supply of fresh air to maintain this standard may be very easily determined. For the purpose of calculation, 0.6 cubic feet per hour is accepted as the average production of carbonic acid by an adult at rest, and the proportion of this gas in the external air is as four parts in 10,000. If, therefore, the degree of vitiation of the occupied room be maintained, say at 0.6 parts in 10,000, there will be permissible an increment of only 2 parts in 10,000 above that of the normal carbonic acid in each cubic foot of air. The 0.6 cubic feet of carbonic acid produced per hour by a single individual will, therefore, require for its dilution to this degree 0.6 divided by .0002, equals 3,000 cubic feet of air per hour. Upon this basis the following table has been calculated:

Cu. ft. of Air containing 4 parts of carbonic acid in 10,000 supplied per person.

Per Hour . .	6000	4000	3000	2400	2000	1800	1714	1500	1200	1000	525	375	231
Per Min. . .	100	66.6	50	40	33.3	30	28.6	25	20	16.6	9.1	6.2	3.8

Degree of vitiation of the air in the room. (Parts of carbonic acid in 10,000.):

5	5.5	6	6.5	7	7.33	7.5	8	9	10	15	20	30

The figures indicate absolute relations under the stated conditions, and are generally applicable to the ventilation of schools, churches, halls of audience and the like, where the occupants are reasonably healthy and remain at rest.—*Ventilation and Heating by B. F. Sturtevant Co.*

OXYGEN FOR CUTTING METALS

The cheapness with which oxygen is now procurable and its portability and convenience of handling is leading to its being more and more thought of in the planning of industrial economies and to its actual and profitable employment for many purposes. M. Leon, in *Genie Civil,* describes an important application of oxygen to the cutting of metals as practiced in France.

At the Say refineries a jet of oxygen was employed some six or seven years ago, not for actual cutting, but for breaking down old pipes and I beams. The metal was first heated to the temperature of fusion by a blowpipe and then, discontinuing the application of the

heating gas, a stream of pure oxygen was later applied to the heated metal. The operation was in two parts, first the heating of the metal and later burning it away. It was possible in this way to break up the metal into different parts, but the operation produced a very large and heavy cut with many blisters, and it was found impossible to secure a clean separation by this method. It has been successfully applied, however, to breaking down metallic connections in blast furnaces.

The method as at present developed is a great improvement on the old. The apparatus consists of two blowpipes which operate simultaneously; the first, an ordinary oxy-hydrogen or oxy-acetylene blowpipe, heats the metal to the desired temperature; the other, attached to the first and following it at a distance of a few millimeters (an inch or two), projects upon the heated metal which is heated by the first blowpipe, burns under the influence of the oxygen; there is formed an oxide more fusible than the metal itself, which is driven forward by the strength of the oxygen jet. The resulting cut is extremely clean, with no appearance of blistering.

In view of the numerous applications which may be made of the method, a number of different devices have been developed for various kinds of work. Cutting along a straight line, as for steel sheets, armor plate, etc., is accomplished by the use of a traveling carriage, carrying the blowpipe, which is driven by an endless screw. In this apparatus also the blowpipe is mounted on a swinging arm which permits it to trace out arcs of circles. Several of these devices are used for cutting armor plate at the French arsenals and navy yards.

A rolling device, consisting of a blowpipe mounted on a crosshead carrying an adjustable roller at each end, may be used for making either straight or beveled cuts. This apparatus is also provided with a swinging arm for the cutting of circles or spirals. The device is largely used by the Chemin de fer du Nord for cutting T rails.

For cutting pipes, the blowpipe is mounted on an annular ring which is clamped to the pipe and around which the blowpipe revolves. By means of this device pipes up to 300 mm. (12 inches) in diameter may be cut in place. A universal portable apparatus is so arranged as to admit of cutting out any desired section, the blowpipe being guided by cams of special shapes. Other devices may be applied to cutting circular openings of 30 to 350 mm. (1¼ to 14 inches) diameter in plates of any thickness, to cutting shafts up to 130 mm. (5 inches) diameter, and lastly for cutting openings of any radius in steel pipes for the purpose of making elbows, the bevel being cut in the end of the other pipe by the same machine. For the preparation of two pipes of 150 mm. (6 inches) diameter in this way the time taken was four to five minutes, a great improvement on the 30 to 40 minutes required by other methods.

To cut a manhole 300 by 400 mm. (12x16 inches) in a plate 20 to 30 mm. (¾ to 1¼ inches) thick takes from four to five minutes. A pipe fitting, 150 by 150 mm. (6x6 inches), in a pipe 5 mm. (3-16 inch) thick, takes three to four minutes and costs 12 to 15 centimes (2.3 to 2.9 cents), while the same operation could not be performed by hand in less than 35 to 40 minutes.

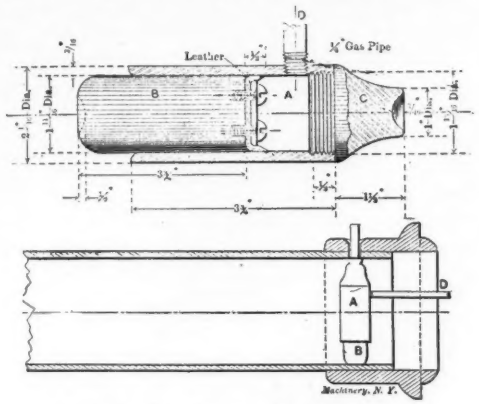
In one case a steel stairway was cut through in a quarter of an hour. A workman cut through 130 T irons, 200 mm. (7¼ inches) high, imbedded in cement, in three hours. The system has been largely used in the French navy yards for the breaking up of ships and has been found very satisfactory in many applications. It is particularly useful in deriveting plates; the head of a rivet can be burned off in less than 12 seconds without injuring the plate itself.

The maximum thickness which has been cut by this method up to the present is 210 mm. (8 inches) in armor plate, but a thickness of 300 mm. (12 inches) has been attained in round shafts. A number of tests have been made to determine whether the cutting by this method has any effect on the physical properties of the metals. Under the microscope the steel appeared quite unchanged, and other tests by shock, etc., showed its strength to be absolutely unimpaired. On this account and considering the cheapness and rapidity of the process, there are prospects for a wide and growing use of the system in the near future.

The Lily-Jellico Coal Company, Lily, Ky., has 600 acres of coal seam 4 feet thick, with 10 feet of earth over it. The earth is to be removed by shovels when all of the coal will be recovered. When operations are under way the excavation will provide its own dumping ground.

A SPECIAL PNEUMATIC DOLLY

The sketch of the pneumatic dolly here shown was sent to *Machinery* by Mr. M. H. Westbrook of Port Huron, Mich. It is used for "holding on" while riveting bolt joint rings on the ends of locomotive dry pipes. The device is not altogether new, but many shops should be glad to adopt it and this full dimen-



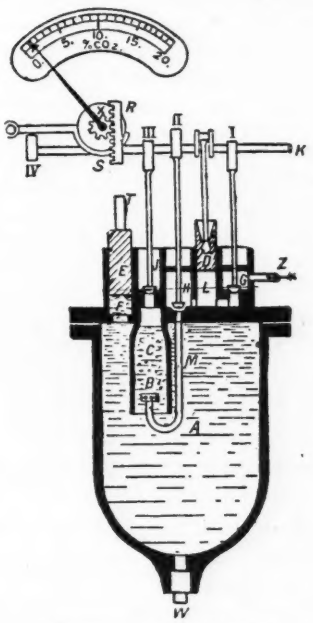
A SPIRAL PNEUMATIC DOLLY.

sioned sketch will be welcomed. The cylinder *A* has a head *C* screwed into it, this head being reduced in diameter and cupped to fit the head of the rivet. The plunger *B* is pocked with a cup leather as shown, the outer end also being cupped for a rivet head and also rounded so that it may bear between the heads of rivets when that will give the more correct position. Compressed air is admitted or discharged by the pipe *D*. The lower figure shows the dolly in use with a new rivet in position. The air forces the plunger *B* against the wall of the pipe or head of a rivet opposite, holding the rivet tightly in place, the operation of riveting closing the joint completely.

THE COOMETER, FOR ANALYZING BOILER FURNACE GASES

This is an automatic apparatus for the boiler room patented in England by Schlatter & Deutsch. The cut is taken and the description here given is adapted from the *Iron Age*. Like a pressure gage, it can be mounted in a convenient position where the stoker can watch its indications and be guided in his firing. Since it makes four records a minute, an almost instant and practically continuous knowledge may be had of the condition of the fire.

A steam motor for continuously rotating the shaft K is an essential part of the apparatus. A connection is made at Z with a small pipe from a point where a fair sample of gas may be withdrawn, and the gas, after passing through a filter, is introduced at constant pressure when the valve G is opened. This valve is operated by the crank I on the shaft K and is opened while the piston D is making its upstroke. Before the latter begins its down stroke the valve G is closed and the valve H is opened by the crank II. The gas, which has been drawn into the chamber L, is then forced out through the tube M and disperser B into the bell C. This bell is



SECTION OF COOMETER.

in communication with the vessel A, containing a solution which absorbs carbon dioxide. The measured quantity of gas, as determined by the volume of the chamber L, is reduced according to the content of CO_2, and the remainder of the gas, rising as tiny bubbles to the top of the bell C, displaces its volume of the liquid into the chamber F, raising the piston E. At this instant the crank IV releases the brake S, allowing the rack R to descend until it touches the rod T. The amount that R descends is proportional to the volume of CO_2 absorbed, and the pointer, which is rotated through the pinion X by the rack, plays

over a scale calibrated to read directly in per cent. of CO_2. At the lowest position of the piston D and the highest position of the piston E, respectively, the crank disk IV again tightens the brake S against the disk X, restoring the pointer to zero and holding the rack R while the discharge valve J is opened by the crank III, allowing the gas collected in the bell C to be exhausted by the weight of the piston E, and another charge is drawn into the chamber L and analyzed as before. In addition to the indication afforded by the dial a permanent record is made on a drum by perforations on a continuous strip chart which is moved by clockwork. The point records made on this chart are regulated in height by the travel of the rack R, and the fluctuations of the curve traced show how well the firing has been performed. As a matter of course, special care is taken that the materials employed for all parts shall not be corroded or attacked by the gases or liquids, and that the cylinder F shall always contain a neutral solution and not an alkali.

With certain modifications, it is stated that the coometer can be used for registering the analyses of other kinds of gases, such as those in gas engines, gas generators, gas stokers of any kind, and still further applications are possible in chemical, ceramic, sugar and other industries.

DRYING AIR FOR THE BLAST FURNACE

The following we take from an address by James Scott before the Pittsburg Foundrymen's Association:

To-day ore is being got from the Lake Superior regions carrying 13 to 14 per cent. water and less than 50 per cent. of iron; and it is taking two tons of ore to make one ton of iron in many of the furnaces of the Pittsburg district. Some of them require even more than two tons of ore to the ton of iron. In other words, for every ton of iron of 2,240 pounds made, two tons of ore are consumed, and therefore that much more gangue. You get that much irregularity in your blast furnace. Therefore we must use more coke to consume that gangue—we must use more limestone, and limestone is the most refractory material put into the blast furnace.

Coke to-day is not as good as it used to be. It is very much higher in sulphur, and much higher in ash, and therefore more of it is required. And the more we use the more sulphur we get, coke giving us the greatest amount of sulphur we get from any material in the blast furnace. Also the larger the volume of coke the greater the variation is going to be in pig-iron. It will be harder for the furnacemen to get a uniform product.

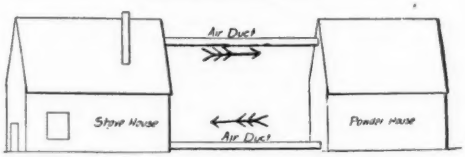
In our American climate everyone knows the benefit of dry air. The blast furnace loses energy. What is the reason? Simply because you are pumping water into it, and where there is appreciable water in the furnace it will lower your silicon and raise your sulphur as well as change your graphite carbon into combined carbon. It makes poor iron. We want to overcome that, but water is one of the elements you cannot decompose unless at the expense of silicon. In order to realize the decomposition that must take place inside of the blast furnace when you are pumping air saturated with water—last year in the month of August, and at the beginning of September, we pumped as high as 11 grains of water to the cubic foot. When you know that a great many of the modern furnaces to-day are pumping as high as 55,000 cubic feet of air a minute and 11 grains of water to the cubic foot, you can figure that there are 20 to 40 tons of water per day pumped in. That water pumped into the blast furnace must be decomposed. How? By the carbon there. If we pump that water in, we are robbing our furnace of heat. If we did not rob the furnace of heat by the pumping in of water, we would have that much more fuel to reduce the oxide of iron from which we get the pig-iron.

We take the air and dry it—we freeze the water out of the air. From eight grains on the average for nine months in the year—six grains per cubic foot in the winter time and just as variable in the summer months—we have on very cold nights taken the moisture down to less than one-half a grain to the cubic foot. In daytime as the temperature rises the moisture rises.

The first great benefit of the dry air—refrigerated air—is that there is no variation. We maintain the air uniformly at one and one-half grains to the cubic foot. We do not pump the large amount of water into our furnace, and therefore we do not require so much coke. And if we do not have to put so much coke in we do not have to take care of the sulphur in that extra amount of coke. Further, we do

not have to put in so much limestone to take care of the sulphur; so that we not only have the great advantage of uniformity from dry air, but less trouble from sulphur. This is more important when you consider that all cokes that we have to use to-day are almost 33 per cent. higher in sulphur than they were ten years ago.

If we eliminate the moisture in the atmospheric air we can reduce 15 per cent. more iron ore, and often 18 per cent.; and if we have what we call a favorable mixture on, I have seen as high as 20 per cent. But 15 per cent. can be guaranteed.



FOR THAWING DYNAMITE

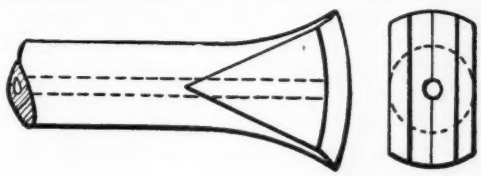
The sketch, from *Engineering-Contracting*, shows an arrangement for thawing dynamite as used by the Tanana Railroad Construction Company, building the Alaska Central Railway. There are two small houses about 20 feet apart and connected by the air boxes at top and bottom, as shown. The dynamite is placed in the house at the right and there is a stove in the house at the left. The air being perfectly free to move naturally, flows in the direction indicated by the arrows, and the desired temperature is obtained in the dynamite house without suddenness of change and without excess of heat.

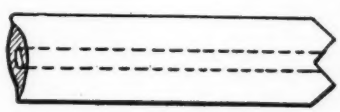
SUCCESS OF THE GAYLEY DRY BLAST

The Warwick furnace No. 2, at Pottstown, Pa., has been equipped for running with dried blast by the Gayley system with highly satisfactory results. There has been an increase of 5 per cent. in the output and a decrease of 11.7 per cent. in the coke consumption per ton of iron and some incidental gains of importance have also developed. The furnace was about to be blown out at the end of August, but since the dry blast installation had then been finished it was hoped that the new method would prolong the life of the furnace for a time sufficient to finish certain urgent contracts for basic iron. This proved true, and it is estimated that the life of a lining is prolonged 32 per cent. by the dry blast method. Moreover, it was found that an unexpectedly high increase in percentage of the desired grade of metal was obtainable.

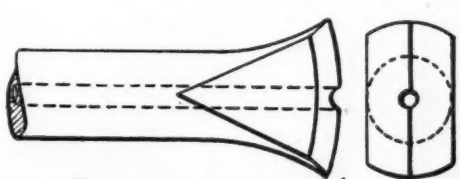
A NEW ROCK DRILL BIT

The bit here shown, the cut adapted from the *Mining Journal* (London), is the invention of Mr. William Charles Stephens (R. Stephens & Sons). Mr. Stephens introduced the now indispensable hollow drill bit. With the single chisel bit the hole not only takes away a small portion of the cutting edge but also has a tendency to elongate after forging or become more or less oval, thus taking away still more of the chisel edge. The improved bit here shown is called the double parallel edge chisel bit. With the old bit the hole came





Double chisel bit.



Single edge chisel bit.

through the cutting edge of an inverted Λ. With this new bit the apex of the inverted A is cut V-wise, so that the hole is not only protected but is unaffected by the forging, no matter how often repeated.

The double cutting edge to the chisel bit confers more advantage than at first appears. It can be forged, it is claimed, in about a minute and a half as against twenty minutes to make an X bit by hand. Further, the old type chisel bit occasionally produced a three-sided, and the cross or X bit a five sided hole, while the double-edge chisel bit, no matter at what angle, always gives a perfectly round hole from start to finish and in any kind of rock.

A THOUSAND TONS OF COAL AND A HUNDRED MILLION GALLONS OF WATER A DAY

The records of the great Cunard Atlantic liners, the Lusitania and her so-called sister, the Mauretania, are watched with augmented interest as time passes. It is not denied that the coal consumption is about 1,000 tons every twenty-four hours. It may be a little less or a little more. The bunkers hold 7,000 tons. How much remains in them at the end of each trip is only known by a select few. We take it for granted, however, that each ship burns 1,000 tons of coal every twenty-four hours—that is to say, the contents of the trucks of two 50-car coal trains, one train for the day and the other for the night. As there are twenty-five boilers, each boiler must take 20 tons per day and the same every night.

It may be assumed that, the boilers being Howdenised and the coal good, each pound of coal will make 9 pounds of steam; that is to say, no less than 9,000 tons of steam are made every twenty-four hours, or, neglecting fractions, 375 tons of steam pass per hour through the engines. As the pressure is about 200 pounds absolute, each pound of steam will occupy about 2 cubic feet, which means that 1,680,000 cubic feet of steam pass through the engines every hour.

These are large quantities, but they shrink when compared with the flow of water through the condensers. That will be about fifty times the weight of the feed-water, or $50 \times 9{,}000 = 450{,}000$ tons per twenty-four hours, or 312 tons of water every minute, or 100,800,000 gallons per day. To realize what this means, it will suffice, perhaps, to say that the quantity would represent the water supply at 35 gallons per head per day of a city with nearly three million inhabitants, or almost enough for the city of Paris.

Turning to the furnaces, we have equally astounding figures. Allowing 20 pounds of air per pound of coal, we have 20,000 tons of air passing through the grate bars every day. Taking the temperature of the supply at 100 degrees, we have 14 cubic feet of air to the pound, so that 26,100,000 cubic feet of air enter the furnaces every hour. A pipe 10 feet square would pass this quantity if the speed were that of a great gale—50 miles an hour.—*The Engineer,* London.

OXYGEN REQUIRED FOR BREATHING

The amount of oxygen required varies enormously with the degree of bodily activity, and, to a lesser extent, with the individual concerned. A man at rest uses about 0.3 litre (18 cu. in.) per minute, while severe exertion raises the consumption to 2 litres (122 cu. in.) per minute; a degree of activity corresponding to walking three miles per hour requires rather more than 1 litre (61 cu. in.) per minute.

The volume of air breathed cannot be indefinitely increased, and the breathing of air which is deficient in oxygen is an imperfect stimulus to deeper or more frequent respiration. It is, therefore, necessary that the percentage of oxygen in the air breathed should be maintained as well as the total quantity available for use. It is undesirable that the percentage of oxygen in the air breathed should fall much below that in outside air (21 per cent.), and it is definitely dangerous to breathe a mixture containing as little as 10 per cent. oxygen, especially while doing muscular work. There is no considerable physiological advantage in increasing the percentage of oxygen in the mixture breathed beyond 20 per cent.

The symptoms resulting from breathing air deficient in oxygen are insidious and indefinite. The first obvious symptom, however, especially in persons not particularly directing their attention to the matter, may be sudden loss of consciousness. It is, therefore, absolutely necessary that some definite warning of the failure of oxygen, not dependent on personal vigilance or sensations of giddiness or the like, should be given to the wearer of a rescue apparatus before the percentage of oxygen has fallen to a dangerous limit.

The physiological effects of breathing air containing an excess of carbonic acid are usually obvious. Air containing 5 per cent. causes definite panting, which at 6 or 7 per cent. becomes distress; even 4 per cent. produces unpleasant increase in respiration (hyperpnœa), and greatly reduces the capacity of doing hard work. It may be stated in a general way that 3 per cent. is the maximum permissible, while it is desirable that the percentage should not rise much above 1 per cent. Definite symptoms of poisoning do not appear—at any rate in the course of a few minutes—until the percentage rises to 10 or 15.—*Report of Royal Commission on Safety in Mines.*

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

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KELVIN

Peace and the grace of God abide with thee,
Fallen with weight of everripened days!
Thou canst not hear how men forbear to praise
For grief the world has lost thy majesty.
How shall we more exalt thy fame's degree,
Or to thy memory enduring raise
More lofty tribute than thy Learning lays
Upon thy tomb? What words of eulogy
Are needed more to save thy cherished name
From unremembered annals of the dead?
But with the great of every land we bow
In sorrow, while with loftiest acclaim
Thou to thine everlasting rest are laid
With crown of noble works upon thy brow.

WILBUR MORRIS STEIN.

LIBELING THE AIR COMPRESSOR

A certain *consulting physicist* is filling space in one of our mining exchanges with such statements as the following:

"The packing of the piston rod and of the piston itself must be extremely tight to withstand air leakage, since the air is a much more volatile material than steam and the leakage problem is much more severe. Thus the friction of modern reciprocating air compressors is great, even in theory, and this friction factor does not diminish under any circumstances with continued use. Many air compressors operate with fully 60 per cent. of the power used in overcoming dead friction in the cylinder and bearings. Hence, the object to be attained in selecting an air compressor is to cut down this friction to as small an extent as possible by constructive detail. The friction of the piston is directly proportional to the diameter of the piston, and the volume of air compressed varies with the square of the diameter. The larger the machine that can be installed, at least as far as cross-section of the cylinder is concerned, the better is the type from an efficiency standpoint."

This belief that air has a mysterious volatility or tenuity is a superstition held by certain users of air and quite widely by those who talk about using it, but there is no foundation of fact for such a belief. Air is no more "volatile," practically no finer in ultimate texture, than steam or water, and no more precautions are required for securing tight piping and non-leaking valves, pistons and stuffing boxes in the case of air, hot or

cold, than for steam or water. The statement that many air compressors lose 60 per cent. of their power in friction is absurd in its recklessness. There is no regular air compressor in existence which will show such a loss, and the writer of the above, we believe, would find it impossible to adjust a compressor to show this friction loss and at the same time keep running as a compressor. It happens that the friction loss in a steam-driven air compressor is precisely indicated by the difference in the horsepowers shown by the cards from the air and the steam cylinders. There are Corliss air compressors of the highest efficiency in which the friction loss is under 5 per cent., and 10 per cent. is a sufficient friction allowance for the average machine.

Then, in addition to the above friction loss, there is the loss by clearance, which is explained as follows:

"No compressor is constructed in which the piston drives out completely the enclosed air. A small space must be left for the operation of the machine, and this space is technically known as the 'clearance volume.' If the clearance volume is large, the compressor operates inefficiently. A certain amount of air is compressed and only a portion of it escapes through the valve. The remainder held in the clearance volume expands on the return stroke of the piston and acts precisely as a spring, and the work done is not available any more than a continued compression and expansion of a spring would be were it fastened to the piston rod outside of the cylinder. For a given cross-section of the piston this clearance volume occupies a percentage of the entire volume in direct proportion to the length of the stroke. On this account the object in air compressor construction is to make the cylinder as long and narrow as possible to cut down the clearance volume."

The loss, so called, in an air compressor on account of the unavoidable clearance is not one of efficiency, but of capacity. A little less than the cylinderful of air is compressed and delivered, but there is practically no power lost for the compression of the air not delivered, as in its re-expansion it helps to propel the piston, or returns the work of its previous compression. Lengthening the stroke does not reduce the clearance in the same proportion, as the actual clearance must be greater with the longer stroke to compensate for the greater springing of the material and the larger play to be allowed with the larger working diameters of pins and journals.

We are told that in a multi-stage compressor "'clearance volumes' are often increased, for there are now several cylinders operating." In any such case only the clearance of the first or intake cylinder counts as to capacity, for whatever passes that cylinder must go through the others.

COMPARISON OF TUNNEL PRACTICE IN SOUTH AFRICA AND COLORADO

In our November issue there appeared an article entitled "Multiple Arrangement of Drills on the Rand," from the *Engineering and Mining Journal.* The publication of this article naturally challenged comparsion with American practice, and the following, by request, was prepared by Mr. W. P. J. Dinsmore, of Denver, Colorado, this also appearing in the *Engineering and Mining Journal,* from whose columns it is here reproduced. The writer calls attention to an article written by himself for *Mine and Quarry,* giving figures covering a rapidly driven tunnel in the Cripple Creek district of Colorado. He then proceeds:

Taking the figures from these two articles we have the following comparative table:

	Rand.	*Cripple Creek.*
Size of bore	5x7 ft.	9x9 ft.
Rate of progress per mo.	225 ft.	375 ft.
Number of machines used shift	3	2
Number of men employed per shift	8	6
Number of holes drilled per round	15	20
Length of shift, hours	8	8
Max. distance over which spoil had to be trammed	800 ft.	8500 ft.

From the above figures we can strike averages and derive the following:

	Rand.	*Cripple Creek.*
Lineal feet advance per shift	2.43	4.03
Cu. ft. rock broken per shift	85.05	326.43
Percentage of advance, lineal feet	60%	1.66
Percentage of advance, cu. ft.	26%	3.84
Percentage of machines used	150%	0.66
Percentage of men used	133%	0.75
Percentage of holes drilled per round	75%	1.33

The work on the Rand was carried on with

a greater number of men and machines. The article in the *Journal* also brings out the fact that the Rand tunnel was driven to single track size to be later widened to accommodate double tracks. Not so with the Cripple Creek tunnel, which was at all times kept up to its required width.

That there must be causes for the difference in speed as shown above, is self-evident. These causes must rest upon four things, viz., the hardness of the rock; the method employed in doing the work; the efficiency of the men; and the efficiency of the machinery.

The rock encountered in the Rand tunnel was undoubtedly harder on the average than that in the Cripple Creek tunnel, though some of the rock at Cripple Creek was probably as hard. The cylinder diameter of the drills used in the Rand tunnel was 3¾ in. and that of the Cripple Creek drills was 3⅛ in. The drills in the Rand tunnel put in on an average five holes each per shift, while those in the Cripple Creek tunnel averaged 10 holes each per shift. In view of these facts it would hardly seem that the rock, even if much harder on the Rand, could be held entirely responsible for the difference in the speed accomplished.

It may be that the Rand tunnel was being widened at the same time that the heading was being advanced, in which case it is possible that the tracks over which the spoil from the heading was being trammed were more or less blocked by the drills and the broken rock at the point where widening was in process. This blocking, if extensive enough, might well be the cause of delays in getting the spoil away from the heading and thus delay the work of advancing the heading. From the data that we have at hand, this would not seem to be the case, and it would appear that a round of holes was drilled and shot each shift. Therefore, it would not be right to charge delays to this until further confirming information be secured.

The fact that the Rand tunnel was driven smaller than the Cripple Creek tunnel may also account for some delay. While it would naturally seem that a small tunnel could be driven faster than a large one, at the same time this has not always been the case. The larger tunnel in some cases can be driven faster than the smaller tunnel owing to the fact that the rock breaks more easily. The powder having a larger face to work on, consequently breaks deeper per round, and the larger tunnel also gives more room in which the drillmen and shovelers may work, so that a round of holes is drilled fully as quickly in the larger tunnel, or even more quickly, and the additional size gives the shovelers the additional room necessary to get out a larger amount of rock.

The difference in the speed of drilling can hardly be charged up to the hardness of the rock. Therefore, it would seem that it must be charged either to the method employed, i. e., that of driving a small tunnel instead of a larger tunnel, or to the efficiency of the men or machines employed.

THE MECHANICAL MISSIONARY

The power-driven rock drill is a mechanical missionary, and one of prolific accomplishment. It is a doer of good in large measure, so that the works of the conscious, purposeful, professional beneficent are belittled by comparison with it. The wealthiest man who ever lived could not have given to the world a tithe of what this thumping, punching and apparently rough-and-ready device has contributed. Its work is essentially the simplest that could be thought of, merely to perforate Earth's cuticle in predetermined spots. Only to make the holes is all that is demanded, and no precision of either location or dimension is required. Yet this simple operation and the apparatus which has made it easy to do afford, perhaps, the most striking enforcement of the dictum that every cause is productive of more than one effect. In the case of the rock drill as a cause the effects of it are innumerable and many of them reach far beyond our ken.

The first notable work of the rock drill was in the driving of the Hoosac tunnel, a task so hopeless before its advent that the time of the tunnel's completion was suggested by the Autocrat of the Breakfast Table as the end of all things and the period for the donning of our ascension robes. The tunnel was easily enough bored when the rock drill got at it, and the tunnels it has driven since and the open cuts are only to be measured by the thousands of miles.

But that was only the beginning, and only one of the many special lines of employment which the rock drill has made for itself. If it now has one specialty upon which it may pride itself more than another, and by reason of which all mankind are most indebted to it, the specialty is mining, the unlocking of the

treasures of Earth. Whether it is lead or silver or gold, or the vastly more valuable copper and coal and iron, these all it makes free to man to use as he will for every purpose that may be devised. The rock drill works to the greatest depths and has been the sole means of reaching the greatest depths below the surface, and it works equally well in the open to the limits of accessibility in the mountains. In its unearthing of treasure it goes to the remotest corners of the globe, so that the one special area in which it is most numerously employed to-day is not in the seats of civilization, ancient or modern, but in the farther corner of the dark and so long unknown continent. On the Rand in South Africa, and not in the metropolis of either the Old or the New World is where the rock drill is the most numerous and the busiest. And it goes not alone to the remote and hitherto inaccessible and uninhabitable regions where the mineral treasures are most likely to be found stored. It is always in touch with the spirit of the age and draws after it all the agencies and the facilities of civilization and plants them everywhere to stay. It is banishing the savage from the Earth. The railroads, which lace the continents, and the canals, from sea to sea, are the creations of the rock drill, and in the promotion of universal intercourse and mutual knowledge and a recognition and full appreciation of the common interests of the race it is foremost.

As illustrative of the diversity of effects which may follow the single cause it is to be remembered that the air compressor, as a machine of established manufacture, became so upon the demand of the original rock drill. For a long time the almost sole employment of the compressors, when first built in numbers and of respectable size and efficiency, was the driving of the rock drills which had called them into being, the field of their first activities being almost exclusively in mining and tunnel work. The supply of compressed air by the presence of these compressors being made easily attainable, the diversifying employments and the multitudinous variety of compressed air tools and appliances rapidly developed.—*Cassier's Magazine.*

In 1906 the production of natural gas in the United States was 388,842,562,000 cubic feet, or 9,396,864 short tons, the value of which, reckoned at $5 per ton, was $46,984,320.

UNPROMISING LIQUID AIR

At a recent meeting of the South Wales Institute of Engineers, liquid air having been spoken of for use in a mine rescue apparatus, had made him a little skeptical as to the practical usefulness of various adaptations of liquid air. The great thing was to have the liquid air at hand when wanted, and always ready in real emergency. For power purposes, liquid air could not be produced more cheaply than by expending one pound of coal for every pound of liquid air, whereas one pound of coal could be got to raise ten pounds of steam; so that one pound of coal would produce power the equivalent of at least twenty pounds of liquid air. Then for refrigerating purposes, liquid air compared unfavorably with ice, because one pound of coal would produce from fifteen to eighteen pounds of ice, and, weight for weight, ice was as good a refrigerating agency as liquid air. It did not produce such an intense cold, but as much useful cold could be gotten out of a given quantity of ice as from the same quantity of liquid air, and, as he had said, it required fifteen times as much coal to produce a given quantity of liquid air as it did to produce a similar quantity of ice. The only important industrial use to which liquid air had been put was in the production of oxygen by a process of distillation, but on the scientific side it had been the means of discovering important properties of substances at low temperature, including those of the emanations of radium.

QUESTIONS AND ANSWERS

Q.: How many cubic feet of free air per minute will flow through a 1-inch and also a 2-inch pipe, 1,000 feet long, under 117.6 and 157 pounds, gage, pressure?

A.: The volume of air flowing through a pipe in a minute, or other period of time, depends upon both the initial and the terminal pressures. Our working formula is as follows:

$$v = \sqrt{\frac{2{,}000d^5(p_1^2 - p_2^2)}{l}}$$

in which

v=cubic feet of free air per minute.
d=diameter of pipe in inches.

l=length of pipe in feet.
p_1=initial absolute pressure.
p_2=terminal absolute pressure.

The above formula may be transformed to get the different values as follows:

$$l = \frac{2{,}000 d^5 (p_1^2 - p_2^2)}{v^2}$$

$$d^5 = \frac{v^2 l}{2{,}000\ (p_1^2 - p_2^2)}$$

$$d = \sqrt[5]{\frac{v^2 l}{2{,}000\ (p_1^2 - p_2^2)}}$$

$$(p_1^2 - p_2^2) = \frac{v^2 l}{2{,}000\ d^5}$$

In the present question with the first set of conditions, that is, 1-inch pipe and 117.6 initial pressure, we assume a loss of pressure of 10 pounds, which would make the initial absolute pressure, or p_1, 117.6+14=132.3, and the terminal absolute pressure, or p_2, 132.3—10=122.3. Then applying these values in the formula, we have:

$$v = \sqrt{\frac{2{,}000 \times 1^5 \times (132.3^2 - 122.3^2)}{1{,}000}}$$

$$v = \sqrt{\frac{2{,}000 \times 1 \times (17{,}503.29 - 14{,}957.29}{1{,}000}}$$

$$v = \sqrt{\frac{2{,}000 \times 1 \times 2{,}546}{1{,}000}}$$

$$v = \sqrt{5{,}092}$$

v=71.35 cubic feet per minute.

With the 2-inch pipe, 157 pounds, gage, pressure and assuming a loss of 15 pounds, our solution would be as follows: 157 gage + 14.7=171.7 absolute initial pressure and 171.7 —15=156.7 absolute terminal pressure. Then

$$v = \sqrt{\frac{2{,}000 \times 2^5 \times (171.7^2 - 156.7^2)}{1{,}000}}$$

$$v = \sqrt{\frac{2{,}000 \times 32 \times (29{,}480.89 - 24{,}554.89)}{1{,}000}}$$

$$v = \sqrt{\frac{2{,}000 \times 32 \times 4{,}926}{1{,}000}}$$

$$v = \sqrt{315{,}264}$$

v=561.48 cubic feet per minute.

W. M. S., Batson, Texas. *Q.:* I understand the law is that, the temperature remaining the same, the volume of a given quantity of air is inversely as the pressure which it bears, but I do not fully comprehend this. By the above law, doubling the pressure would halve the volume of air, the pressure remaining the same, but in a certain Air Compressor Catalogue appears this extract from COMPRESSED AIR: "The diagram shows that when a volume of free air is compressed adiabatically to 21 atmospheres (294 pounds, gage pressure) it will have a volume of a little more than one-tenth." I understand that adiabatic compression would leave a larger volume than isothermal, but should there be that difference?

A.: In all these operations it is to be remembered that only absolute pressures and temperatures are dealt with. In compressing to 21 atmospheres the ratio of absolute pressures would be 1-21=.0476 and the ratio of volumes under isothermal compression would be the same, but the ratio of volumes at the termination of adiabatic compression to 21 atmospheres would be .1149, or reciprocally 8.668 instead of 21, so that the statement that the volume would be "a little more than one-tenth" was not an exaggeration. Approximately the same result may be reached in corroboration of the above by a different process. In adiabatic compression from 1 to 21 atmospheres from an initial temperature of 60 degrees the final absolute temperature would be 1,259 degrees, and the ratio of initial and final temperatures would be $\frac{60+461}{1259} = .4138$. Then the ratio of volumes would be 1:4138:: 21:8.689, which is quite near the 8.668 found above. It is expected that a later issue of COMPRESSED AIR will contain formulas, tables and diagrams which will be of great assistance in computing the relative pressures, volumes and temperatures which occur in air compression.

TRADE PUBLICATIONS

The Fuller-Lehigh Pulverizer Mill, Lehigh Car, Wheel and Axle Works, Fullerton, Pa., 44 pages 9x12 inches. This expensively printed publication, with numerous half-tones, describes the pulverizer mill to its minutest detail, and gives accounts of various installations.

The Westinghouse Storage Battery Auto-Truck for Industrial Railways. The Westinghouse Machine Company, East Pittsburg, Pa., 18 pages 6x9 inches. This pamphlet, with fine half-tones and not overwritten, describes a line of flat trucks for use in transporting working material in factories and yards upon the tracks, usually narrow-gauge, of "industrial" railways. Everything is below the flat top of the truck, but readily accessible. At a nominal cost for power, and not requiring skill to operate, the car moves itself and load wherever required.

The Treatment of Belts and Ropes for Service and Profits. Cling-Surface Company, Buffalo, N. Y. 88 pages 4½x7 inches. Well described by the title. A great variety of conditions and applications of belting are treated of.

The "De La Vergne" Two Cycle Vertical Oil Engine, De La Vergne Machine Company, foot of East 138th street, New York. This is an 8-page folder 4x9 inches, describing a new line of engines built by this company. The engine uses kerosene or fuel oil, about a pint per horsepower hour. There is no carburetor and no valve motion, and the engine is one of the simplest ever devised. It is safe, reliable, economical, and runs at high speed, occupying little space for the power developed.

Abbreviated Catalogue, The Whitney Manufacturing Company, Hartford, Conn. 12 pages 6x9 inches. Shows chains, "Whitney" machine keys, key-seat cutters, checks, tapping devices, millers, grinders, etc., made by the company.

Small Steam Driven Air Compressors. Ingersoll-Rand Company, New York; 38 pages, 6x9 inches. This catalog, handsomely printed and copiously illustrated, describes the smallest steam driven compressors of both the Ingersoll and the Rand types with the latest improvements on each as built by the present company. The capacities range from 30 to 500 cubic feet of free air per minute and the gage pressures from 15 to 100 pounds.

KELVIN AS AN INVENTOR

There are three kinds of inventor—the man who comes on discoveries accidentally, generally when looking for something else; the enthusiast, often a little ignorant, who works at a problem with a kind of instinct, and solves it by a stroke of genius which no one can explain; and the educated technologist, who, finding a door difficult to open, merely selects from the given stock of knowledge the proper key to open it. Kelvin belonged to the last category. His great inventions, such as his compass, his mirror galvanometer, his syphon recorder, and his electrical measuring instruments, all depend on alterations in degree of something that went before. He also developed his inventions by a curious method. He never seems to have been able to sit down and make a drawing of, say, an instrument. He would have an experimental model made from instructions, and would then alter it about until it satisfied him, and then it would be copied as it was. The result was that all his instruments looked as if they ought to be re-designed by a good engineering draughtsman. Kelvin's inventions were often great, but it was because his available knowledge was great, and, though they would be remarkable for an ordinary man, they are really dwarfed by his greatness in other directions.—*The Engineer.*

THE DEGRADATION OF NIAGARA

It is many years now since the Niagara River was first called upon to pay tribute to modern industrial needs, and was, as the phrase goes, "harnessed" to an alternator, as though it were a horse harnessed to a whim. The draught of power is measured now by the million horse-power, but up to the present the majestic Falls have remained to all appearances unharmed, and nothing can be said against the wise and prudent use of the vast supply of energy thus reclaimed from Nature's stores.

We learn, however, from the American papers that the amenities of the Falls are endangered in another way altogether. The authorities of the city of Niagara Falls have commissioned the General Electric Company

to install batteries—we might call them parks—of large searchlights, with which to illuminate the Falls, and the work is actually in progress. Beams of all the colors of the rainbow are to be projected upon the falling waters, under the control of "an operator manipulating a keyboard" so as "to obtain a thoroughly artistic interpretation of the color scheme"—*artistic!* To crown this scheme of vulgarization, the Falls are to be assisted—faked—boosted—for their natural resources are inadequate to satisfy the doers of this vandalism. In fact, a steam boiler is to be used, to discharge "clouds of steam" from pipes "to augment the mists," so that "artistic" cloud effects may be produced, with the aid of the searchlights. Bombs will be thrown also, to burst over the Falls and emit heavy clouds of smoke or a shower of . . . *confetti.*

Alas! How are the mighty fallen! The monster has been harnessed; now it shall be tortured, to make a Yankee holiday. Shame! —*Electrical Review,* London.

REAL RAILROAD VALUES

The following is the opening paragraph of a valuable, suggestive and informing address recently delivered by Robert Mather before the Chicago Association of Commerce:

If the rails of the land should melt over night, the loss to-mrrow morning would be less in the falling quotations of railroad bonds and stocks than in the utter destruction of the values on farms and in mines and mills and factories that to-day we count as the nation's wealth. Such sudden and miraculous solution of the problem is, of course, unlikely; at least it has not yet been advocated in Presidential speech or message. But any diminution of the industrial efficiency of our transportation lines would affect in like manner, though in lesser degree, all the varied interests that would go down to destruction with the annihilation of those lines. It is not alone, therefore, the few thousands who own the securities of the railroads, or the million and a half employees engaged in their operations, or the ten millions whom the wages of these employees support, that are directly and peculiarly interested in the proper solution of the railroad problem. The question comes home as well to the pockets of the millions of farmers and miners and millers and manufacturers and merchandisers, with all their added millions of dependents. In short, it is a question that touches us all, not because the charge for transportation is a large element in the cost of what we consume, but because without efficient railroad transportation our commerce could not be profitable. The gross earnings of all our railroads for the fiscal year ending June 30, 1907, were $2,325,765,167. Divided among the population this would be $25 each. A 33 1-3 per cent. reduction in freight and passenger rates would mean $8 per annum for each of us, but a reduction by one-third of the capacity of our transportation lines to move the tonnage of the country would mean ruin to us all.

A BIG BLAST SAVES $10,000

C. F. Johnson, who has the grading contract for eighty-five miles of the Chicago, Milwaukee & St. Paul Railroad west of Ellensburg, Wash., recently cleared $10,000 in a fraction of a minute. He sent $7,000 up in smoke and $17,000 worth of grading was done in a jiffy.

Alexander Holman, who directed the work, tells the story as follows:

"It is a little more than a year ago that I began sizing up that rock hump and figured on the best way to handle it. I got my men to work, and by slow and tedious drilling we excavated eight pockets for the powder. We ran eight small tunnels, just big enough for the men to work in, directly into the face of the rock shoulder. When the right point was reached we ran tunnels to the right and left.

"We stowed away in the eight pockets 1,771 kegs of black powder and dynamite enough to bring the total up to the equivalent of 1,800 kegs. This represented about 55,000 pounds of powder. When the shot was ready for the electric wires the cost was $7,000. Naturally, the greatest care was taken with the wiring. In order to make sure of accurate work, I rigged two batteries and set them away up the side of the mountain behind the biggest tree we could find. I want you to note that we piled all our drills, hammers and other tools at a point a considerable distance above the mine and behind another big tree. A mighty curious thing happened to that pile of tools, as I will tell you later.

"When all was ready and everybody warned in all directions I touched the buttons of the two batteries, and then things happened quickly. The whole point of rock trembled, and

when the great bulk of the twenty thousand yards of stone were hurled into the lake it created a sort of a tidal wave that made the water rise three feet on the shore opposite more than a mile away. The water marking on the rock on the lake shore immediately adjoining the blast showed that the water surged back and swelled up six feet.

"All we have to do now with that hump is to roll out 5,000 yards of rock, and then we stand 25,000 yards to the good. Instead of the slope being shattered so that we would have to take down and out a lot of dead work, the fact is that the slope is just as perfect as if the cut had been made by piecemeal. Of course, the fact that we will have no dead work is unusual, for some can be safely counted on in blasts of this size.

"Now, the curious thing about that pile of tools was this: A rock that will easily weigh several tons was thrown high enough to go over the top of a group of fir trees that stood immediately above the blast. It never scratched the trees nearest the blast, but in coming down it side swiped a big fir two feet through, sending it down with a crash, and lit squarely on top of the pile of tools, with a result that can be imagined."

NOTES

The name of *Technical Literature* has been changed to *Engineering Digest,* which more accurately describes the scope of the publication. It collects, selects and condenses a wide variety of fresh technical matter and is already a valuable addition to the means of information accessible to the up-to-date technical man whatever may be his specialty.

The Mining Reporter, weekly, and *Ores and Metals,* semi-monthly, both of Denver, are now consolidated into *Mining Science.* Geo. J. Bancroft, M. E., is to be editor-in-chief of the new publication with W. H. Graves and H. J. Baron, former editors of *Ores and Metals* and of *The Mining Reporter,* respectively, as associate editors.

A new channel is to be excavated for the Sturgeon River, Michigan, to carry it away from the Loretto mine. A considerable quantity of rock and 500,000 cubic yards of earth will have to be moved. This will release a large body of ore directly under the present bed of the stream.

Sunken ships may now be refloated by means of acetylene gas. An experiment was recently successfully tried on a ten-ton boat in the River Seine. The boat was raised by means of small balloons inflated below the water with acetylene gas immediately generated from the solid carbide of calcium by the action of the water, which made the operation practically automatic.

The Rove tunnel, for the canal from Marseilles to the Rhone, will be the largest, but not the longest, in the world. In cross-section it will be 72 feet wide and 46 feet high, with a 6½-foot roadway on each side for an electric railway. The material to be removed will be double that of the Simplon tunnel. The estimated cost is about $7,000,000 and seven years will be required for the work.

When an issuing U. S. patent has more than five claims those above that number are now not printed in the *Patent Office Gazette.* This quite naturally reduces the bulk of each issue, reduces also the cost of printing and is in every way to be commended. The claims printed are always sufficient to give an idea of the patent, although even those are never fully intelligible without a copy of the specifications and drawings, which any one may have, with, of course, all the claims, for five cents. And yet there are some to find fault with this exercise of common sense in the Patent Office.

For years, says the *Iron and Coal Trades Review,* the steel industry has confidently expected to see a fulfilment of the prediction made long ago that "the open-hearth process will go to the funeral of the Bessemer." Recent developments indicate rather clearly that the function will be a wedding instead of a funeral, a vastly more happy occurrence. The duplex process is rapidly gaining in favor, and the details are being worked out in different ways by different metallurgists. It is more a matter of appliances and manipulation than processes, as the metallurgical work is laid out very clearly.—*The Engineer.*

The mechanical engineer is one who by science and by art so adapts and applies the physical properties of matter and so controls the forces which act through them as to serve the use and convenience of man and to advance his economic and material welfare. He does this mainly by storing and liberating motor energy through machines and apparatus which he designs and installs and operates for the purpose of fostering and developing the processes of industrial production which use and require such power upon a large scale.—*Pres. Hutton before the Amer. Soc. Mech. Eng.*

Our readers will remember the striking pictures shown in our December issue of the caissons which are being sunk under the Seine for one of the Paris subways. We regret to note that a serious accident has occurred in the placing of them in position, entailing loss of life and serious additional cost and delay. On December 23 one of the sections, from some cause, became displaced and the outrushing air caught five of the workmen, crushing and killing them instantly. The entire workings were immediately flooded so that the total damage is not known, and the righting of things may be a novel and in any case a serious engineering problem.

One of Kelvin's most astonishing characteristics was his avidity for work. He was as enthusiastic at eighty-three as at twenty-three, and he seemed to work always. He really loved work, and he never tired of it. He was a standing refutation of the theory that a man does no good work after forty. It is much more likely that we all get lazy at forty to forty-five; but those who work hard from forty to fifty without succumbing, remain active all their lives, and probably prolong their active existence considerably.—*The Engineer.*

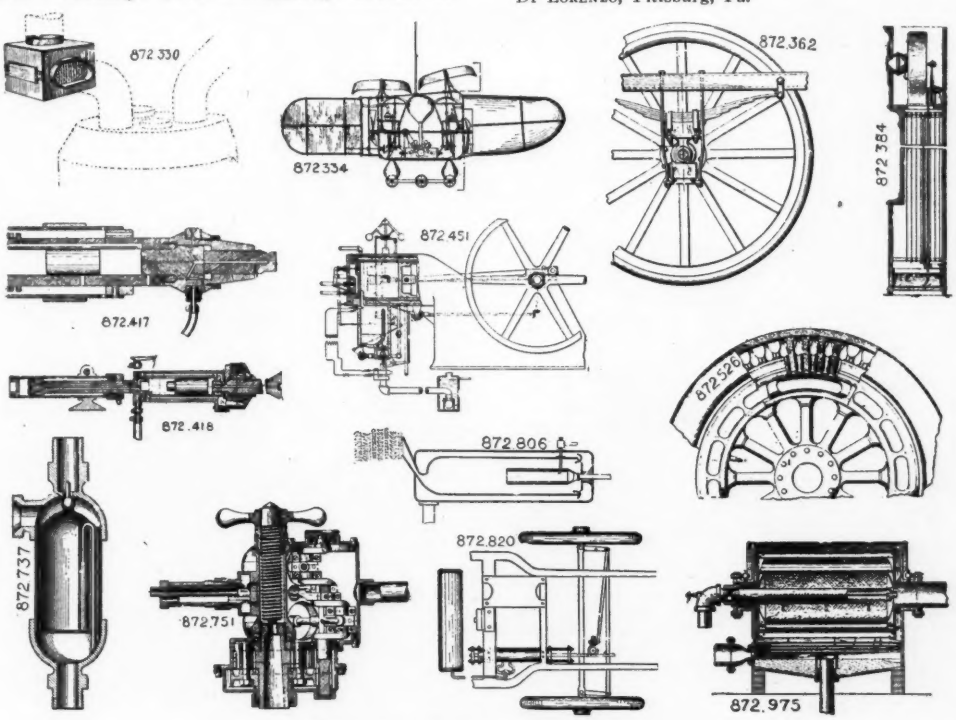
LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

DECEMBER 3.

872,330 AIR-MOISTENER FOR FURNACES. William A. Cunningham, Winona, Minn.

872,334. AIR-SHIP. Aurelio S. Fadda and John Di Lorenzo, Pittsburg, Pa.



Pneumatic Patents December 3.

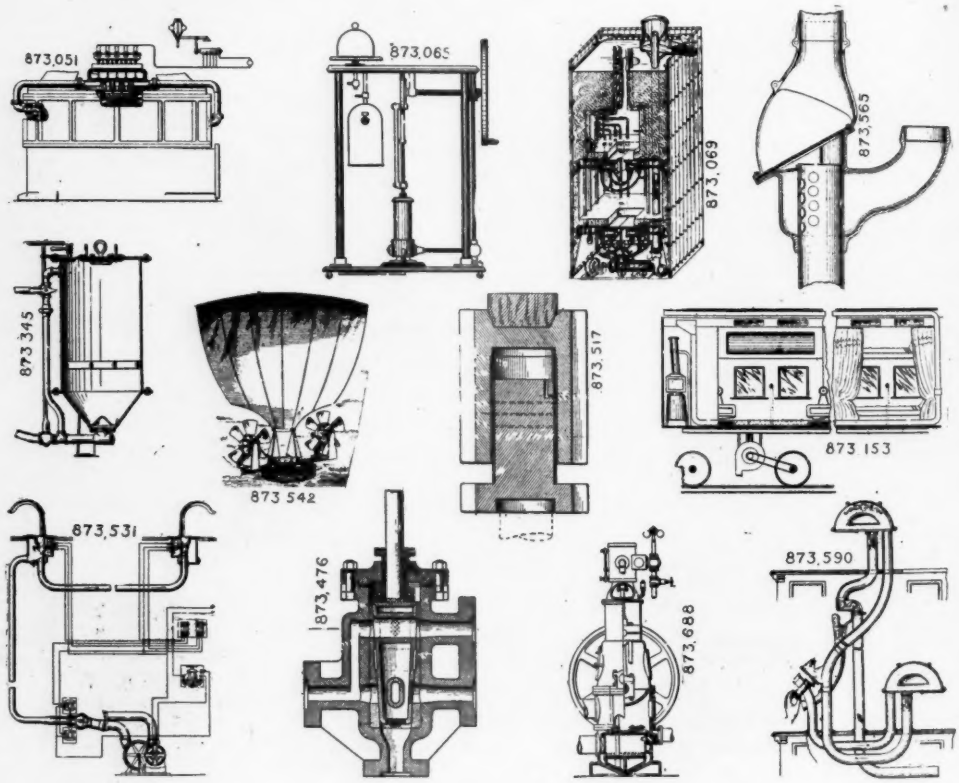
872,362. PNEUMATIC SPRING AND SHOCK-ABSORBER FOR MOTOR-VEHICLES. Albert L. Muren, Belleville, Ill.
872,384. HUMIDIFIER. Joseph J. Smith, New York, N. Y.
872,417. ROCK-DRILLING MACHINE OR ENGINE. Henry Hellman and Lewis C. Bayles, Johannesburg, Transvaal, South Africa.
872,418. ROCK-DRILLING MACHINE OR ENGINE. Henry Hellman and Lewis C. Bayles, Johannesburg, South Africa.
872,451. CLEARANCE-CONTROLLING MECHANISM FOR COMPRESSORS AND MOTORS. Sidney A. Reeve, Worcester, Mass.
872,526. PROTECTED PNEUMATIC TIRE. Carl G. Lotave, Denver, Colo.
872,737. AIR-VALVE. Doctor F. Morgan, Chicago, Ill.
872,751. PNEUMATIC MOTOR. William F. Rothe, East St. Louis, Ill.
872,806. ELASTIC-FLUID TURBINE-ENGINE. Sebastian Ziani de Ferranti, Hampstead, London, England.
872,820. AIR GUIDE OR STEERING DEVICE FOR AUTOMOBILES. James T. Johnson, Memphis, Tenn.
872,868. PNEUMATIC STRAW-STACKER. James A. Walsh, Indianapolis, Ind.
872,975. APPARATUS FOR WASHING GAS. Charles E. Sargent, Chicago, Ill.

DECEMBER 10.

873,051. ELASTIC-FLUID TURBINE. Oscar Junggren, Schenectady, N. Y.
873,065. AIR-PUMP. George H. Mohler, Fremont, Nebr.
873,069. CAISSON CONSTRUCTION. A. Z. McLeod, New York, N. Y.
873,153. SYSTEM FOR VENTILATING PASSENGER-CARS. Nelson S. Mercer, Omaha, Nebr.
873,345. PNEUMATIC GROUT MIXING AND DISCHARGING APPARATUS. William L. Canniff, New York, N. Y.
873,476. VALVE FOR FLUIDS UNDER PRESSURE. Harry Woods, Steubenville, Ohio.
873,517. COMPRESSED-AIR-CUSHION BLOCK FOR PILING. Clinton C. De Witt, St. Louis, Mo.
873,531. PNEUMATIC-DESPATCH APPARATUS. Edmond A. Fordyce, Boston, Mass.
873,542. AERIAL VESSEL. George Halliday, Superior, Wis.
873,565. TERMINAL FOR PNEUMATIC-DESPATCH-TUBE APPARATUS. Isaac W. Litchfield, Boston, Mass.
873,590. PNEUMATIC-DESPATCH-TUBE APPARATUS. Albert W. Pearsall, Lowell, Mass.
873,688. COMBINED WET AND DRY AIR PUMP. Royal D. Tomlinson, Milwaukee, Wis.

DECEMBER 17.

873,725. PNEUMATICALLY-OPERATED GONG. Fred B. Corey, Schenectady, N. Y.
873,740. PNEUMATIC-DESPATCH-TUBE APPARATUS. Edmond A. Fordyce, Boston, Mass.
873,776. REVERSING MECHANISM. Sven T. Nelson, Chicago, Ill.
873,801. SWIVEL FOR ROCK-DRILLS. Samuel A. Sizemore, Leadwood, Mo.
873,813. ROCK-DRILL AND OTHER PERCUSSION-TOOL. Thomas Warsop, Coniston, England.
873,829. PNEUMATIC STACKER. Byron G. Baker, Minneapolis, Minn.
873,924. HUMIDIFYING AND AIR-MOISTENING APPARATUS. Stuart W. Cramer, Charlotte, N. C.



Pneumatic Patents December 10.

873,938. PNEUMATIC HAMMER. MARTIN HARDSOCG, Ottumwa, Iowa.
873,947. TRAIN-PIPE COUPLING. GEORGE E. KELLY and GEORGE F. ROYER, Wilkes-Barre, Pa.
873,948. TRAIN-PIPE COUPLING. GEORGE E. KELLY and GEORGE F. ROYER, Wilkes-Barre, Pa.
873,984. COMPRESSED-FLUID CHARGING AND DISCHARGING DEVICE. GABRIEL A. BOBRICK, Los Angeles, Cal.
874,034. DISCHARGE-VALVE FOR FLUID-COMPRESSORS. WILLIAM PRELLWITZ, Easton, Pa.
874,054. AIR-BRAKE SYSTEM. FRANK H. DUKESMITH, Meadville, Pa.
874,065. HAIR-DRYING APPARATUS. RICHARD GRAPE, New York, N. Y.
874,066. ATMOSPHERIC CLOTHES-POUNDER, SAMUEL D. GRIFFITH, Curwensville, Pa.
874,137. AUTOMATIC PRESSURE-REGULATOR. CHARLES P. TOLMAN, New York, N. Y.
874,212. PNEUMATIC FAN. CHARLES KUDERER, Allegheny, Pa.
874,229. CONTROLLING MECHANISM. JOHN J. NEF, Chicago, Ill.

In a fluid pressure governor, the combination of a reciprocating rod, means for moving the same in one direction by fluid pressure, a spring for moving the rod in the opposite direction, toggle-members pivotally connected at one end, a pivotal support for the other end of one of said members, a support for the other end of the other member permitting axial movement of said member as the toggle is buckled, parts on said rod adapted to engage the toggle when the rod is reciprocated and between which the toggle can move free of the rod, a spring acting on the toggle to continue movement thereof started by one of said parts, a movable circuit-controller independently pivoted on said pivotal support for one of the members of the toggle, and a loose connection between said toggle-member and controller whereby the former actuates the latter when operated by the spring acting thereon, substantially as set forth.

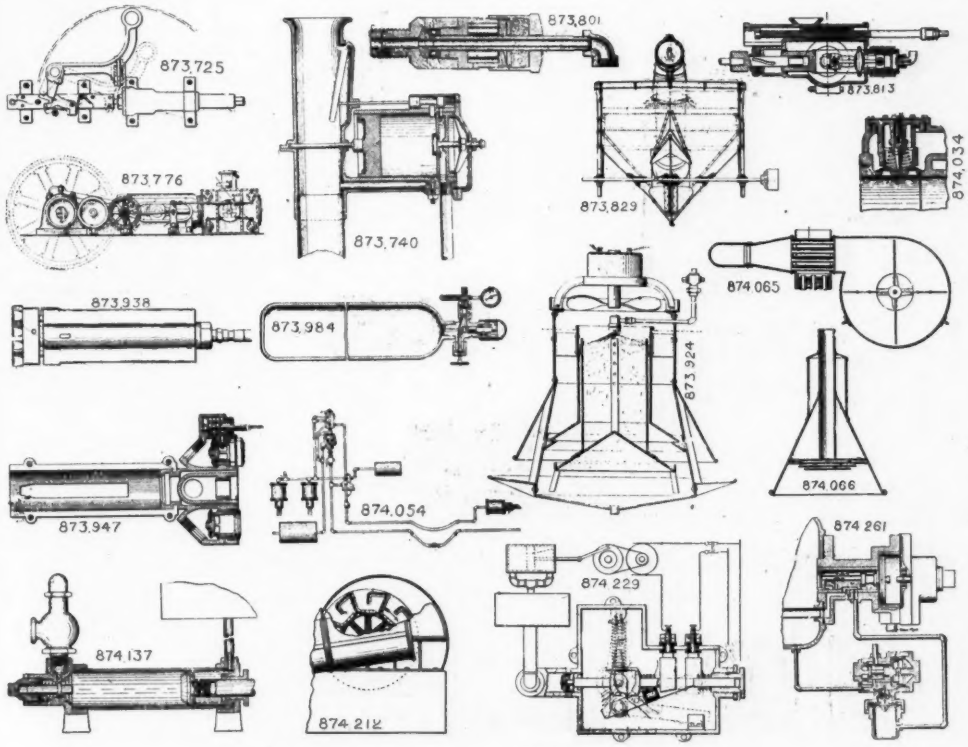
874,261. GRADUATED-RELEASE-VALVE MECHANISM FOR FLUID-PRESSURE BRAKES. WALTER V. TURNER, Wilkinsburg, Pa.

DECEMBER 24.

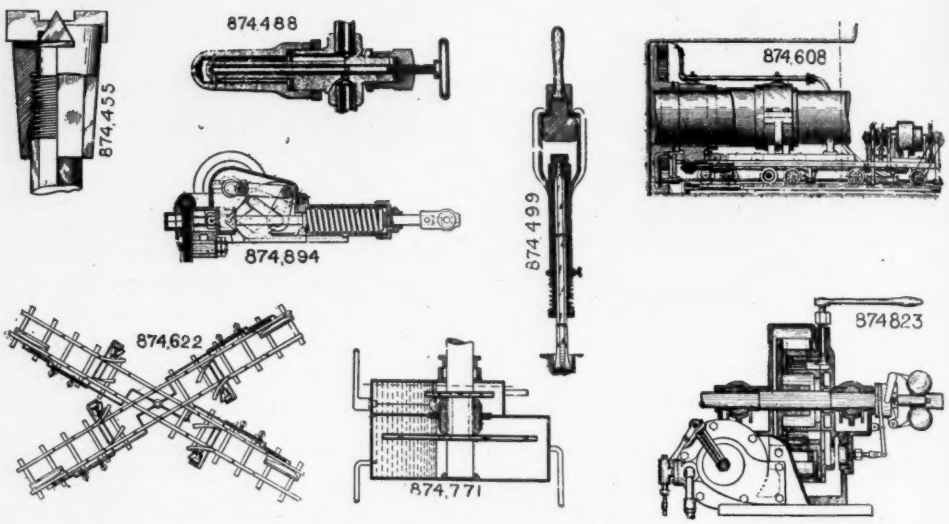
874,455. ROCK-DRILL. FREDERICK V. W. SWANTON and BURT PRICE, Braamfontain, Johannesburg, Transvaal.
874,488. OIL-BURNER. JOSEPH L. CAUSEY, Kansas City, Mo.
874,499. HAND ROCK-DRILL. CHARLES H. GUNN, Oroville, Cal.
874,603. ROCK-DRILLING MACHINE. ALVA D. LEE, Brookline, and FRANCIS J. E. NELSON, JR., East Boston, Mass.
874,622. PNEUMATIC SIGNAL FOR RAILWAY-CROSSINGS. JAMES W. PIPKIN and HILLARD S. MITCHELL, Wilton, Ark.
874,771. COMPRESSED-AIR MOTOR. THOMAS L. JONES, Hamburg, Germany.
874,823. FLUID-PRESSURE ENGINE. IRVIN E. BARRICKLOW, Antioch, Cal.
874,894. DRILL. GEORGE E. LYNCH, Columbus, Ohio.

DECEMBER 31.

874,960. AIR-PUMP. BENJAMIN HAMANN, Detroit, Minn.
874,986. VACUUM-PRODUCING APPARATUS. CHARLES A. PARSONS, Newcastle-upon-Tyne, England.
875,010. LAMP FOR BURNING CARBURETTED AIR. FRANK W. SUTER, London, England.
875,042. WAVE-MOTOR. EDWARD J. BISSELL, Bay City, Mich.
875,111. ELASTIC-FLUID TURBINE. FREDERICK SAMUELSON, Rugby, England.
875,175. AIR AND GAS MIXER. WILLIAM H. HESS, Dewey, Okla.
875,277. ROTARY VALVE FOR AIR-COMPRESSORS. GEORGE W. MEYER, Sparrows Point, Md.
875,446. PUMP FOR VACUUM-CLEANERS. ARTHUR MESTITZ, Raudnitz, Austria-Hungary.



PNEUMATIC PATENTS DECEMBER 17.



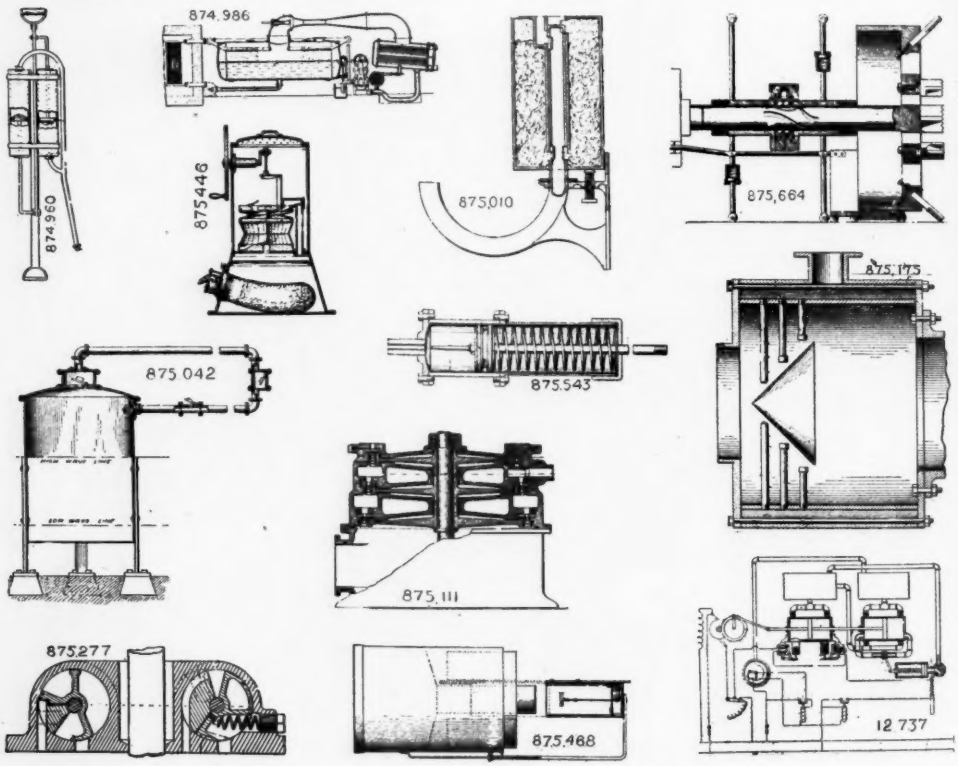
PNEUMATIC PATENTS DECEMBER 24.

875,468. ACETYLENE-GAS GENERATOR. FRANK E. STOVER and CHARLES L. DARNALL, Chattanooga, Tenn.

875,543. AUTOMATIC BRAKE. JAMES LYNCH, Van Buren, Ark.

875,664. TUNNELING-MACHINE. JOHN P. KARNS, Boulder, Colo.

12,737 (Russian). FLUID-PRESSURE SYSTEM. WALTER J. RICHARDS, Milwaukee, Wis.



PNEUMATIC PATENTS DECEMBER 31.